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A Note on a Local Member of the Family Psychodidae Dip

Ella Gemmell

A number of specimens were collected about a drain in a house in Claremont. As they had not been seen here before and as there was no known standing water near, it was a question as to where they had passed their earlier stages. All the specimens were collected in or near the outlet to the small sink. Afterwards it was

found that the cesspool was nearly filled and a new one had to be made, after this the flies disappeared until once again when the cesspool was filled the flies appeared in the house.

These specimens were determined to be *Psychoda cinerea* Bks. this being the synonym for *P. pacifica* as described by Kincaid. The specimens agree in most all parts to Kincaid's description. The specimens were 2 mm. in length. The figure is from a male.

Littoral Ophiurans at Laguna Beach

ARTHUR S. CAMPBELL

During the summer of 1920 specimens of all species of ophiurans previously known to exist near Laguna were obtained.

Several stations were found to be constant with the various species, some for adults, and others for young. Several are limited to very special habitats. Two are limited to but one locality each, while *O. spiculata* is found abundantly in almost all stations examined. For the first time *O. maculosus* was found inshore under stones; previously this species had been known only from kelp holdfasts.

The excellent plates for this paper are the work of Miss E. Keyes, a student in Pomona College.

OPHIODERMATIDAE

No dental papillæ. Buccal papillæ numerous. Two or four genital bursæ in each interradius.

Ophioderma panamensis Lütkin.

Add. Hist. Oph., 2, p. 193. 1859.

Large. Arms, three or oftener four times diameter of disc. Mouth papillæ and teeth small. Arm spines numerous, flattened, lying close to arm. Color dark brown above, lighter below, the arms encircled by pale bands.

Young in *Macrocystis* holdfasts. Adults in rocky tidepools among *Fucus* and green algæ, ranging up to middle littoral tide pools. Common.

Ophiocryptus maculosus Clark.

Third Laguna Report of Pomona College, p. 64. 1915.

Small. Disc covered with swollen plates concealed by rough granules. Upper arm surfaces more or less covered by granules. Oral shields except madreporite, adoral and oral plates covered completely by granules continuous with above. Five almost conical, subequal arm spines. Two tentacle scales. Color white, grey or with disc marked with reddish granules. Disc in young is red, becoming marked later only by a few red granules, and finally dirty white in adult. Seventeen arm joints. Arms one and a half times diameter of disc.

In *Macrocystis* holdfasts, washed inshore under loose rocks. Young and adults intermingled. Rare.

OPHIOLEPIDAE

No dental papillæ. Three or six buccal papillæ. Always two genital bursæ. Disc notched. No tooth papillæ.

Ophioplocus esmarki Lyman.

Bull. M. C. Z. 3, pt. 10, p. 227, pl. 5.

Medium size. Arms nearly three times diameter of disc. Three arm spines. Disc with plates on both surfaces. Disc and arms flattened. Color light or dark brown, some blue-grey.

Young in *Macrocystis* holdfasts, in calcareous sponges and among red algæ in tide-zone. Adults in rocky tidepools among *Fucus* and green algæ; in sand under loose rocks. Abundant.

AMPHIURIDAE

One to five mouth papillæ. Arms arising from ventral side. Two genital bursæ.

Amphiodia barbarae Lyman

Ill. Cat. M. C. Z. Harvard, 8, pt. 2, p. 17, pl. 3. 1875.

Medium size. Arms twelve or more times diameter of disc. Oral papillæ six, equal and regularly arranged. Teeth. No tooth papillæ. Two short, flat tentacle scales. Three tapering arm spines. Color yellowish or tinged with green.

Deep in sand at Balboa. Young in sandy pool on shells. Rare.

Ophionereis annulata Le Conte.

Proc. Acad. N. Sc. Phila., 5, p. 317. 1851.

Medium size. Arms about six times diameter of disc. Mouth papillæ numerous. Teeth. No tooth papillæ. Three flattened, stout arm spines. Color light, arms distinctly banded.

Young in sponge masses. Young and adults among beds of *Mytilus, Lepas* and *Mitella;* in sand under loose rocks, and in rocky tidepools among *Fucus* and green algæ. Common.

OPHIOCOMIDAE

Mouth papillæ. Teeth. Arms arise from ventral side of disc. Two genital bursæ. Mouth shields small or medium.

Ophiopteris papillosa Lyman.

Ill. Cat. M. C. Z. Harvard, 8, pt. 2, p. 11. 1875.

Large and coarse. Arms three or four times diameter of disc. Disc completely covered above by stout stumps. Few mouth papillæ. Five flat, blunt arm spines. Color deep brown, arms often faintly banded.

In rock ledges with ground shell or sandy bases. Associated with the echinoid *S. purpuratus* Stimp. around the mouth region of which there is often a member of this species of ophiuran. Rare and restricted.

OPHIOTHRICIDAE

Plates on upper side of arms small. No oral papillæ. Tooth papillæ. Few buccal papillæ.

Ophiothrix spiculata Le Conte.

Proc. Acad. N. Sc. Phila., 5, p. 318. 1851.

Variable size. Arms five or six times diameter of disc. Disc covered with thorny spines. No mouth papillæ. One tentacle scale. Seven long arm spines. Color greenish brown, red or yellowish. Arms with orange bands. Mouth usually whitish. Some have red discs. Color variation in this species is extraordinary; apparently there is no uniformity.

In *Macrocystis* holdfasts; in rocky tide-pools with *Fucus;* in mussel-beds with *Mytilus, Lepas* and *Mitella.* Young also found in calcareous sponge masses, and

among red algæ in rock tidepools. Very common; the most abundant species found at Laguna Beach.

ASTEROPHYTIDAE

Teeth and mouth and teeth papillæ spiniform, indistinguishable. Arms repeatedly divided.

Gorgoncephalus eucnemis M. & T.

Syst. der Aster. Braunschwig. 1842.

A specimen of this species was obtained several years ago, on a line about 160 faths. some distance from the Laguna shoreline. It measures 130 mm. across the disc.

(*Contribution from the Laguna Marine Laboratory of Pomona College.*)

Fig. 1. *Ophioderma panamensis* Lütkin.
Fig. 2. *Ophiocryptus maculosus* Clark.
Fig. 3. *Ophioplocus esmarki* Lyman.
Fig. 4. *Amphiodia barbarae* Lyman.
Fig. 5. *Ophionereis annulata* Le Conte.
Fig. 6. *Ophiopteris papillosa* Lyman.
Fig. 7. *Ophiothrix spiculata* Le Conte.

(All figures are X2, and of the dorsal surface.)

A List of California Arachnida

This list is compiled from already published but scattered papers. Many of these are local records of specimens and new species collected by many students through a number of years and determined for us for the most part by Banks and Chamberlin. As numerous earlier papers in this Journal have taken up the distribution of local forms only a hint of this will be given. There are included in this list records other than local. If the distribution is general some indication is given. A few hints as to characteristic features are given when possible. The family characteristics are compiled by the aid of the works of Banks, Ewing, Comstock and several others. In order to save space the literature references are given in abbreviated form at the end of each section, especially as there are a number of papers and lists already published which give this material in great detail.

I. PSEUDOSCORPIONIDA

M. Moles and W. Moore

CHELIFERIDAE. Evidences of segmentation of thorax in some species. Serrula attached all its length to finger of chelicera. Spinneret long and slender. Flagellum absent. Tarsi of legs one-jointed. Tarsal claws short and thick, split on some of the feet.

Chelifer cancroides Linn. about buildings, oak, sycamore trees, Claeremont, mts.

C. fuscipes Bks. Calif.

C. scabrisculus Simon. N. Calif. to Claremont.

Chelanops oblongus Say. Palm springs, Brown's flats.

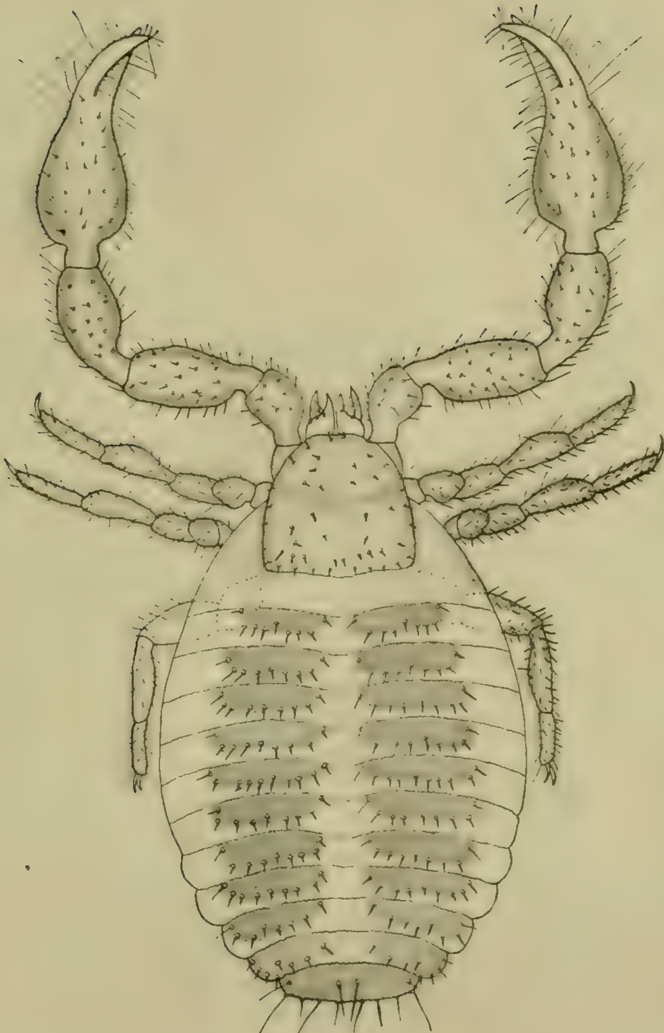
C. validus Bks. From Lake Tahoe.

C. pallipes Bks., under stones Claremont, Los Angeles.

C. dorsalis Bks., Lake Tahoe and San Francisco.

C. acuminatus Sim. Maraposa, Claremont, Laguna Beach.

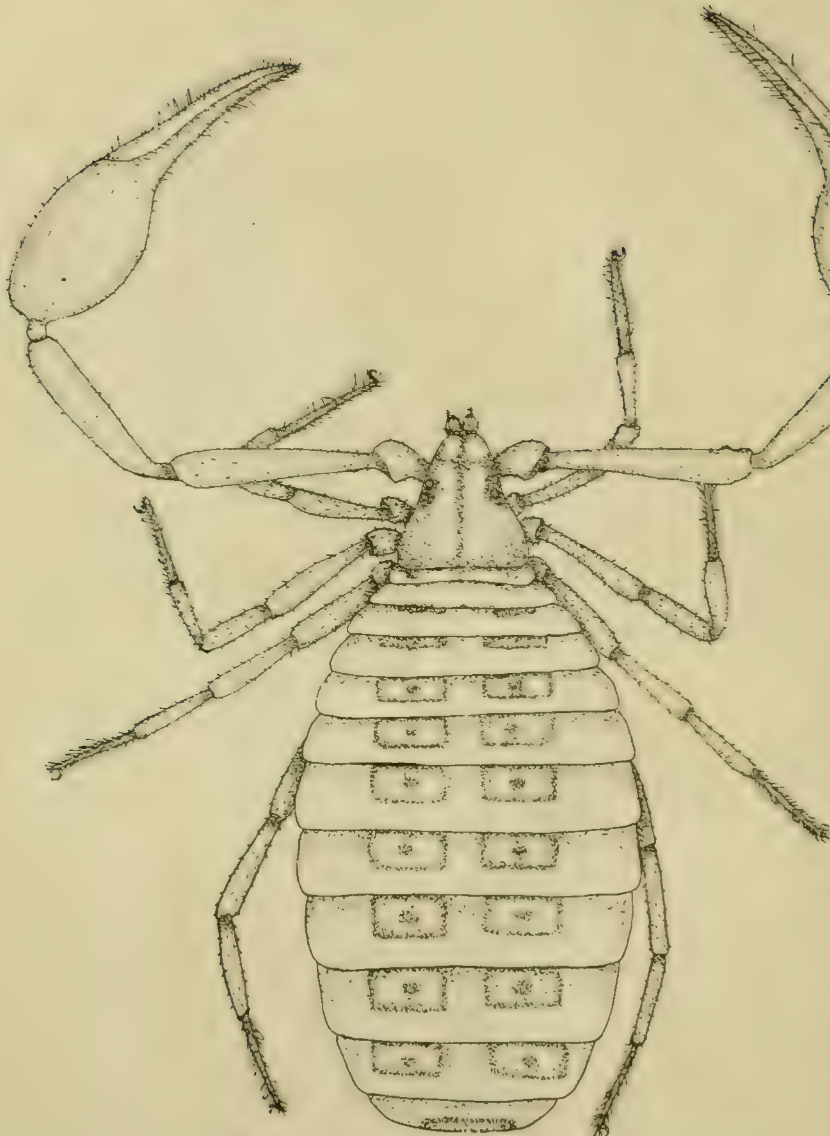
C. lagunae Moles, Two eye spots. Claremont.



C. paludis Moles, Claremont.

C. serratus Moles, No eye spots. Clavate hairs saw-like edge.

Atemnus hirsutus Bks. Laguna Beach near ocean.



Garypus californicus Bks. Under stones Laguna Beach. Also Palo Alto and San Nicolas Island.

Pseudogrypus bicornis Bks. Shasta Springs.

IDEOBSIIDAE. Spinneret long. Serrula attached only at base. Carapace not divided.

Ideobisium magnum Bks. Mt. Shasta. Four eyes.

I. threveneti Simon, Four eyes. San Francisco to Claremont.

Ideroncus obscurus Bks. Lake Tahoe and Claremont.

OBISIIDAE. Spinneret small knob. Serrula attached only at base. Carapace not divided.

Obisium macilentum Simon, Claremont-Mt. Shasta.

Blothrus californicus Bks., S. Calif.

B. magnus Ewing. Shasta Springs.

Linn Syst. Nat. ed. 12, 1767. Ann. Ent. Soc. Fr. 1878. Jour. N. Y. Ent. Soc. 1895. Jour. Ent. Zool. June 1914. Jour. Ent. Zool. Dec. 1911, V. 3, p. 633, 1914, 6, p. 818, p. 6, No. 4, p. 87, V. 9, 1917, p. 26, V. Canad. Ent. 1893, p. 67, also 1891, p. 165.

IV. Coelenterata

HYDROZOA POLYPS. The structure of fresh water *Hydra* has been studied with reference to the nervous system for some time. One of the earlier papers was by Korotneff, '76, who recognized nerve cells. Later work was by T. J. Parker, '80, Rouget, '81, and Schneider, '90. This last author determined a network of ganglion cells to be present. Zoja, '90-'92, finds structures in *Hydra* which he believes are nervous elements because they take special stains and according to him have connections with the epithelial muscle cells and with nematocysts. These cells are similar to the ganglion cells described and figured by Schneider.

Citron, '02, in *Syncoryne* a compound hydroid, finds spindle-shaped sense cells especially in the end knobs of the tentacles. Ganglion cells with three or four processes are found in various parts of the body while bipolar ganglion cells are found in the coenosarc.

Wolff, '03, determined that hydroid polyps have a nervous system, partly of sense cells, partly of ganglion cells. The processes of the latter are more or less joined. The sense cells are primitive intra-epithelial. There is quite a complex network of fibers and cells on the body and tentacles, quite a concentration also on the manubrium. Long strands of the plexus run the whole length of the polyp. There is a less abundant entodermal plexus.

Hadzi in '09, used the isolation method with *Hydra*, also sectioning methods. He found a plexus of nerve cells all over the surface of the body and tentacles; these were chiefly triangular shaped cells. He distinguishes bipolar and tripolar cells as well as some multipolar forms; the first are sense cells. He shows anastomoses at various places. The greater part of the system is an ectodermic network. He says that it is not appropriate to speak of neurones, for the cells are directly connected by protoplasmic processes, and *Hydra* is too far from the type in reference to which the neurone concept was established.

The palm hydroid *Corymorpha*, which is more favorable than *Hydra* for experimentation, has been studied by Torrey '04, Parker, '17, and others.

The reaction systems of coelenterates are cilia, nettle cells, mucous glands and muscles. In this genus, mucous glands and cilia are not important. Nettle cells are apparently independent of nervous control, a condition not true of *Hydra* if we accept the work of several investigators.

There are six sets of muscles in *Corymorpha*; two of these are entodermic, the circular muscle of the stalk and the circular muscle of the proboscis. When anesthetics which control nervous tissues are used, these two muscles remain capable of acting. This probably shows that these muscles are not under control of the nervous

system. The four other muscles, the longitudinal muscles of the stalk, proboscis and the two sets of the tentacles, are quicker in their action and are controlled by anesthetics. These are probably supplied by sense cells and the nerve-net.

Stimuli applied to any part of the normal animal may be transmitted to distant parts; strong stimuli are transmitted to more distant parts than weak ones. The nervous transmission is probably limited to the ectoderm. Although the nervous system is very primitive, reactions much like a true reflex occur, as Parker has pointed out. When a proximal tentacle is strongly stimulated adjacent tentacles respond and the proboscis may turn to the stimulated point.

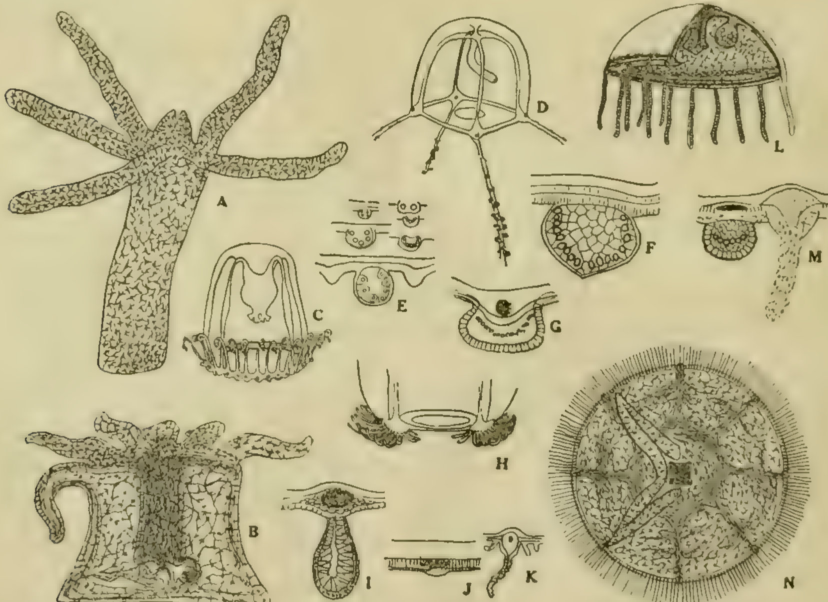


Fig. 4. A. General plan of the nevrous system in *Hydra*. B. Nervous system of *Actinia*. Diagramatic. C, D. Hydroid jellyfish showing position of eye spots. Mayer. E, F. Otocysts of hydroid jellyfish, Mayer. G. Otocyst and eye spot, Mayer. H. Hydroid medusa with eye spots at base of tentacles. I. Tentaculocyst, Mayer. J. Eye spot with biconvex lens, Mayer. K. Tentacle and eye spot, Mayer. L. Diagram of the nervous system of a hydroid jellyfish. Wall of the bell cut away on one side showing section of manubrium and gonad. M. Tentaculocyst and eye spot, Mayer. N. General plan of the nervous system of a scyphozoan, Diagramatic.

Many parts of the polyp are quite independent of the rest of the body, as may be seen when the hydranth has been removed; the stalk will shorten and even localize a stimulus applied to one side. The hydranth is not necessary for coördinated response. Neither

is the stalk necessary for reflex movements of the tentacles and the proboscis.

The neuro-muscular organization of *Corymorpha* is diffuse and in no sense centralized.

HYDROID MEDUSAE. Although the nervous system of medusae is of the diffuse type, there are concentrations of the network at certain places. In *Gonionemus* there is a double ring of nerve cells and fibers about the margin of the bell. Hyde, '02, mentions a third ill-defined ring; this might be considered to be a part of the diffuse network or plexus which is found over the surface of the sub-umbrella. In addition to the two main marginal bands, there are concentrations of nerve cells and fibers following the four radii of the bell, and the manubrium has some concentration of nerve cells and fibers.

Although the nerve ring is usually double, sometimes it is not divided. The nerve tissue is between the ectoderm and the muscular tissue. In some forms the peripheral system is but poorly developed with only a few nerve cells scattered beneath the surface.

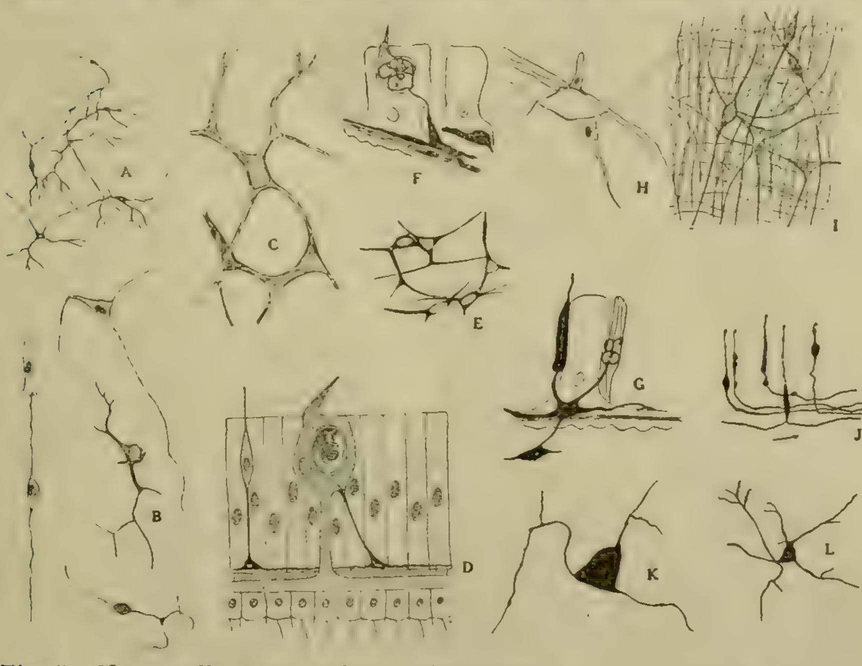


Fig. 5. Nerve cells from various coelenterates from a number of sources. A. Nerve cells from *Hydra*, Schneider. B. Nerve cells and sense cells from jellyfish from Kasseanow. C, E. Nerve plexus from Siphonophora, Schneider. D. Sense cells and nerve cell in *Hydra*. F, G. Nerve cells and fibers in the epithelium of *Hydra*, Wolff. H, I. Nerve cells from actinian, Hertwig. J. Nerve cells from *Cerianthus*, Grosley. K, L. Nerve cells from actinian, Havert.

In *Lizzia,* the Hertwig brothers, '78, found the tentacles grouped, and at the base of these the nerve cord is swollen, due to a concentration of ganglion cells. The suggestion has been made that the two nerve rings have different functions; the upper one connected with the sense organs, the lower being near the muscles gives nerves to them.

Loeb found that if the bell without the nerve ring be placed in five-eighths per cent NaCl or five-eighths per cent NaBr, it goes on beating rhythmically, but small quantities of $CaCl_2$ or KCl or both added caused the bell to stop contracting. The bell would beat in sea water if not for Ca or K, and possibly some other ions.

When two specimens of medusae are grafted together after the nerve rings are removed, the two portions contract as one and not from two centers of contraction.

Krasinska, '14, in *Cormarina* finds large and small ganglion cells and two kinds of sensory cells. The ganglion cells are mostly multipolar and in a sub-epithelial region nerve elements are also found in the tentacles; large ganglion cells are found in the sub-umbrella and small in the tentacles. The velum is enervated by fibers from the inner nerve ring. She does not decide whether there is a true nerve network because she found but few cases of anastomosis. The large ganglion cells of the sub-epithelial plexus are considered to be motor, also the smaller ganglion cells of the tentacles.

In a hydroid medusa, *Tiaropsis,* Romanes found that the manubrium reaches over to a spot stimulated by touch. Romanes found that this movement continued after the margin with the nerve ring was removed.

Loeb explains the coördinating movements of medusae by simple irritability and conductivity without attributing other special functions to the ganglion cells except those which occur in all conducting protoplasm.

Yerkes, '02, determined that the medusa *Gonionemus* has a delicate chemical sense. All portions of the body except the velum and exumbrella are sensitive to chemical and mechanical stimuli. The tentacles are especially sensitive to photic stimuli. The intensity of the stimulus determines the quickness, duration and extent of a reaction. Stimuli which affect symmetrical points of the body unequally have a directive influence upon the movements. Yerkes concludes that the reactions of special parts of *Gonionemus* are not dependent for their execution upon the functional activity of the central nervous system. Irritability is a property of all parts of the animal except the jelly of the bell and the exumbrella surface, but it differs widely in different regions.

As Loeb suggests spontaneity is not dependent upon the central nervous system but upon a high degree of irritability of certain parts of the margin of the bell. Those specimens with the marginal

ring removed do not show spontaneous movements because insensitive to other than strong stimuli.

Coördination is not dependent upon the function of any nerve center, but upon the rapid transmission of an impulse.

Krasinska finds fibrillae within the ganglion cells of hydroid medusae by means of the iron-hematoxylin method.

In *Polyorchis*, Little 1914, there are two nerve rings, the lower being the larger. All the cells are bipolar. Connections between nerve cells and eye were not determined.

Work by Romanes '98 shows nervous connection between the tentacles and also the manubrium.

The sense organs of medusae, marginal octocysts and eye spots

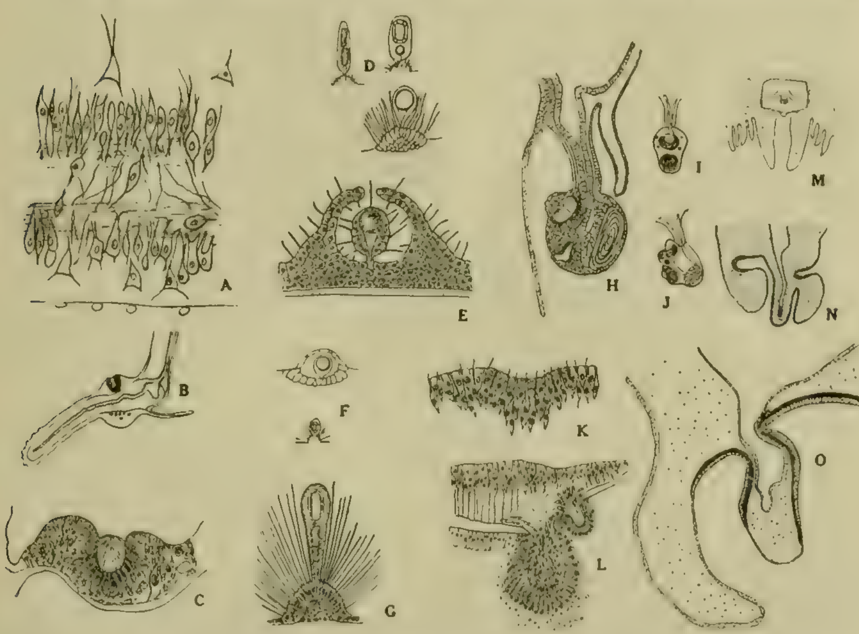


Fig. 6. A. Nerve cells from nerve rings of *Gonionemus*, Hyde. B. Eye spot above lithocyst below tentacle base, medusa. C. Eye spot at base of a tentacle of a hydroid jellyfish, Little. D. Tentaculocysts hydroid medusa, Mayer. E. Tentaculocyst hydroid medusa, Haeckel. F. Tentaculocysts from Trachimedusae, Mayer. G. Tentaculocyst hydroid medusa, Haeckel. H. Section through sense organs, eye spots and otolith of scyphozoan jellyfish. I. and J. Front and side views of scyphozoan jellyfish sense organ. K. Simple eye of medusa Schewaikoff. L. Section through more complex eyes of *Aurelia*. M. Marginal notch and tentacle of *Aurelia* from above. Eimer. N. Section through marginal tentaculocyst of scyphozoan showing sense areas, dark. O. Section through tentaculocyst scyphozoan, Hesse.

E., from Dahlgren and Kepner's Histology. G., M. and N., from Parker and Haswell Zoology, permission of Macmillan Co.

are often found, but the two kinds are not usually in the same animal.

In *Lizzia*, the eye spots are found on the under side of the tentacle, but in this form the tentacle is held up and its lower side turned toward the light.

In *Polyorchis*, Little '14, the eye spot is on the outer surface at the base of each tentacle. In other naked-eye medusae, similar conditions are found; the eyes may be arranged about the margin as in this form, or in groups to correspond with the groups of tentacles.

In genus *Triopsis*, there are eight marginal sense organs consisting of an entodermal ocellus and an open fold of velum which contains concretions. In *Phopalonema* the lithocysts are inclosed.

In the Narcomedusae there are marginal sensory clubs containing concretions of entodermal origin. Romanes, '98, found that if the bell of a hydroid medusa was removed the contractions of the bell cease, but the margin which contains the nerve ring continues to contract as before the injury. Any injury of the umbrella causes no change in the rhythm so long as the nerve ring is intact. The conclusion from this was that the nerve ring is a coördinating center and one needful for rhythmical contractions.

In many medusae, otocysts or senory clubs probably function as static organs. In Anthromedusae there are no otocysts, but many have ectodermal ocelli on the bases of the tentacles. Romanes found that these had certain visual functions. Medusae with them were strongly attracted to light between the red and violet spectrum.

In some forms like *Bougainvillia*, the tentacles are grouped and to correspond to each tentacle at its base is an ocellus or pigment spot.

In the Leptomedusae there may be marginal sensory clubs and there may be lithocysts of ectodermic origin. In some forms such as *Laodicea* there may be marginal sense clubs with no concretions within and ectodermal ocelli at the bases of the tentacles.

In *Orchistoma pileus* Larson, there are four hundred dark brown entodermal ocelli on the circular canal; each is provided with an ectodermal lens.

SCYPHOZOANS. The marginal sense organs of this group are so marked as to be early recognized. Ehrenberg, 1837, was the first to speak of these as organs of sense. The usual type is somewhat as follows. At eight marginal notches we find two small tentacles either side of a shorter hollow tentacle. This tentacle or tentaculocyst contains otolyths and the organ seems to be one of equilibrium. Upon the surface of this tentaculocyst there may be a special pigment spot or ocellus of rather simple structure. In the little flap above and also behind or below the short sensory tentacle there may be special areas of cells which may have some sort of olfactory or

chemical sense. Both Eimer and Romanes published physiological papers in 1877-1878 on work done several years previously which seemed to show that jellyfishes had the power of conducting impulses in a complex manner along their subumbrellar surfaces.

Taschenberg, 1877, was unable to find nervous structures and considered that the muscles responded directly to stimuli without the aid of a nervous system. The Hertwig brothers, 1878, clearly demonstrated the existence of a nervous system in medusae. Schafer, '79, found a network of nerve fibers in the subumbrella lying between the muscular layer and the ectoderm, but did not determine anastomosis. Somewhat later Schlater, 1891, believed he had found the true nervous system in the marginal sense organs, but a clear recognition of nerve cells was again made by Kassianow ten years later. He found a nerve plexus in *Lucernaria* and *Craterolophus*. In the latter, tripolar ganglion cells are also found. He shows sense cells and ganglion cells in direct association with epithelial cells.

Hesse, '95, in *Rhizostoma* shows the structure of marginal sense organs in some detail and gives some indication of the nervous system. Fibers run from the eight marginal sense areas to a more or less circular band which is somewhat poorly defined, and other strands spread out over the subumbrellar muscular bands of the jellyfish. The relation between cells was not clearly shown.

Bethe, '09, was able to prove that the nerve plexus in *Rhizostoma* is a true network.

Romanes and others have shown that the bell of a jellyfish could be cut in a most complex manner without preventing the passage of a stimulus for a contraction wave.

If a single marginal body is stimulated, contraction waves start both to the right and to the left of the stimulation until they mingle and disappear.

If the center of the jellyfish is cut out and the margin deeply notched, the tortuous pathway of tissues thus formed is capable of carrying a contraction wave. If a jellyfish with one marginal sense organ is cut in a spiral strip, a wave of contraction may be started at the margin which will run the whole length of the strip.

A jellyfish cut so as to make two concentric rings with only two slight connections between will carry the impulse from the outer to the inner portion by this narrow bridge. If the jellyfish is cut so as to form a long circular stretch, a wave may course for a long period round and round the bell. Such a "trapped" wave has been known to go for eleven days with no great decline in rate; or at the rate at which it was traveling, it would have covered a distance of four hundred and fifty-seven miles in eleven days, Parker, 1919.

The removal of the marginal bodies of a medusa causes the movements to cease for a time, but it may be made to contract by electrical or chemical stimulus. Experiments by Bethe seem to show

that although the muscle of the jellyfish is capable of direct stimulation, it is not so sensitive as the nerve-net. Parker summarizes the susceptibility to stimulation as follows: 1. Marginal bodies most sensitive. 2. Nerve-net. 3. Muscles directly stimulated least sensitive.

Mayer, 1917, concludes from his experiments with *Cassiopea,* that nerve conduction is due to a chemical reaction involving the cations of sodium, calcium and potassium. The probable high temperature coefficient of ionization of this proteid may account in some measure for the high tention coefficient of the rate of nerve condition, which he finds is two and five-tenths as great as that of the electrical conductivity of the seawater surrounding the nerve. His observations do not support the "local action" theory. The rate of nerve conduction is practically identical whether sea water is diluted with 0.415 molecular mercuric chloride or with distilled water.

Corry, 1917, working with the same species found that regeneration takes place more rapidly on the half of the jellyfish in which the sense organs were not removed. When sense organs are removed and one half stimulated by electricity and the other insulated half not stimulated, regeneration is more rapid on the activated part. The experiments show that the rate of regeneration is but one expression of the general metabolic activity of the animal and as such is subject to the influence of the nerve centers as are many other functional activities. It is concluded as a result of experiments that some chemical interchange between sense organs and the surrounding tissue is necessary in order that the activity of these structures shall be maintained at the highest state of efficiency.

Some sort of trophic influence is exerted in general metabolic activities by the sense-organs. The structure of the nervous system of this form makes it impossible to prove the existence of tropic-nerve fibers as distinct from those of sensory or motor functions.

In *Pelagia,* Krasinska finds large and small ganglion cells in association with sense cells. The large ganglion cells are considered to have a motor and the smaller ones a sensory function. There are three methods of connecting the nerve plexus with the epithelial surface. (1) Through peripheral processes of the ganglion cells. (2) Through sense cells. (3) Through free nerve endings. No direct proof of the enervation of the muscle fibers was established.

The tentacles have large and small ganglion cells, the cells are deep in the muscular folds but in the outer epithelium is a fine nerve-fibrillar area. Similar fiber masses are found in other parts of the body and the nervous system; these may correspond to a "neuropile." Fibrillae were found especially in the branches of the ganglion cells.

ACTINIANS. The reactions of the actinians have attracted at-

tention from qute early times; Milne-Edwards in his natural history of corals in 1857 wrote:

"They enjoy a highly developed sensibility, not only do they contract forcibly on the slightest touch, but they are also not insensible to the influence of light. But no nervous system or organs of sense are to be discovered in them." In these early times there were, however, some vague suggestions of ganglia and nerve chords in Actinia, but no confidence was placed in them. Huxley, in his elements of comparative anatomy of 1864 says: "The nervous system has at present not been determined in them." Alexander Agassiz, in his seaside studies of 1871 says: "Only a few pigment cells found at the tentacles are sense organs."

Schneider and Ritteken, 1871, state that the chromatophores are organs of sense, compound eyes.

J. D. Dana in his Corals and Coral Islands, states that "they sometimes possess rudimentary eyes."

Duncan, 1874, describes in some detail the structure of the "eyes" of actinians. He also recognizes a plexus or network of nerve fibers and cells under the epidermis, and remarks that the diffuse nature of the nervous system is what might have been anticipated.

The first rather complete account of the nervous system was by the Hertwig brothers in 1879-80. They recognized sensory cells in the epithelial layers and under the epithelium and next to the muscular layers of both ectoderm and entoderm a layer of nerve fibers and cells. The sensory cells when stimulated carry impulses to the nerve cell layer and this in turn to the muscles beneath them. Nerve impulses from the ectoderm to the entodermal muscles were supposed by them to pass over the exterior to the oesophagus and from its inner end to the entodermal musculature. They considered the body of the sea-anemone to be rather uniformly supplied with nervous tissue except at the oral disc where in the ectoderm the cells were concentrated in a sort of center. Wolff, 1904, and Grosley, 1909, in the main accepted Hertwigs' suggestions but they placed the concentration of the nerve fibers in the wall of the oesophagus and not in the oral disc.

Kassianow, 1908, in Alcyonaria, believed the disc to be the center of an individual member of the colony and Liedermeyer, 1914, although his observations were of sections alone, was of a similar opinion from his study of one of the Pennatulacea.

Havert, 1901, on a sea-anemone by means of the Golgi method, maintained a diffuse nervous system for actinians. This author also believed that the ganglion cells, so-called by the Hertwigs, were really motor cells which receive impulses from sensory cells and then transmit them to muscles, a condition more like that of the central nervous system of forms with a reflex arc. This author also

showed a direct connection between ectoderm and entoderm, a conclusion which Parker, 1917, and Parker and Titus, 1916, have shown on both anatomical and physiological evidence.

Von Heider, 1877, was of the opinion that the mesenteries of some actinians might contain nervous elements. Wolff, 1904, and Kassianow, 1908, were of the opposite opinion but a number of investigators seem to have shown that Von Heider's opinion is the right one, among them Hickson, 1895, Ashworth, 1899, Kükenthal and Proch, 1911, and Liedermeyer, 1914.

In recent years Parker has given this group considerable attention and some of his conclusions will be employed in the following discussion. There is also a paper on the histology of actinians by Sanchez, 1918, but in this the nervous system is not considered very extensively.

The effector systems of sea-anemone are mucous glands, ciliated epithelium and muscles. Although nematocysts are considered by some to be under control of the nervous system, there is good evidence that they are independent of it. The only system under the control of the nervous system is the muscular. By means of experiments it was learned that the bases of the anemones were especially sensitive, but nervous transmission may be accomplished from almost any portion of the ectoderm to its longitudinal mesenteric muscles. By several experiments it was proved that the transmission might be by means of almost any narrow bridge of tissue, proving quite conclusively that the transmission is by a nerve-net.

Many muscles responded at some distance from the point stimulated and in some cases muscles were capable of responding directly to a stimulus; whether these muscles were also under the control of the nervous system at other times was not clearly established in every case. In the acontia, however, there seemed to be no intermediation of nerve impulses in the response to stimuli. Connections from ectoderm to entoderm was proved in many cases. In connecting the ectodermic and entodermic system the lips and oesophagus seemed not as important organs as other parts of the body.

Although the system of the actinians is diffuse there is some degree of specialization. If the tentacles are stimulated by a nutrient fluid the oesophagus gapes by contraction of the transverse mesenteric muscles, while weak acid causes a retraction of the oral disc by means of a contraction of the longitudinal mesenteric muscles. The two kinds of response suggest independent receptors and relatively independent transmission tracts.

In the tentacles the ectodermal surface is more receptive than the entodermal; if there is a nervous structure in the latter it is probably very simple. The tentacles are complete neuro-muscular organs and may react quite independently of the polyp, as shown when severed from the body.

Parker has measured the rate of transmission of the nerve impulse in sea-anemones at 21 centigrade. It was found to be from 121-146 mm. a second.

Kassianow, Parker and others have studied the nervous system and reactions of colonial forms. There seems to be little evidence of any nervous coördination in colonial polyps, each polyp in *Renilla* for instance when stimulated by contact seems to react independently of the rest. Although the common flesh which supports them may bring about like changes in several or all of the members of the colony, the zoöids are not centers from which impulses pass to other parts.

The peduncle and rachis are probably permeated by a nerve-net which extends from the zoöids of the colony.

Ctenophora. The first observations on the nervous system of this group were by Pschschiltz, 1829, and later by Mertens, 1833. One of the first complete summaries of the general structure of the

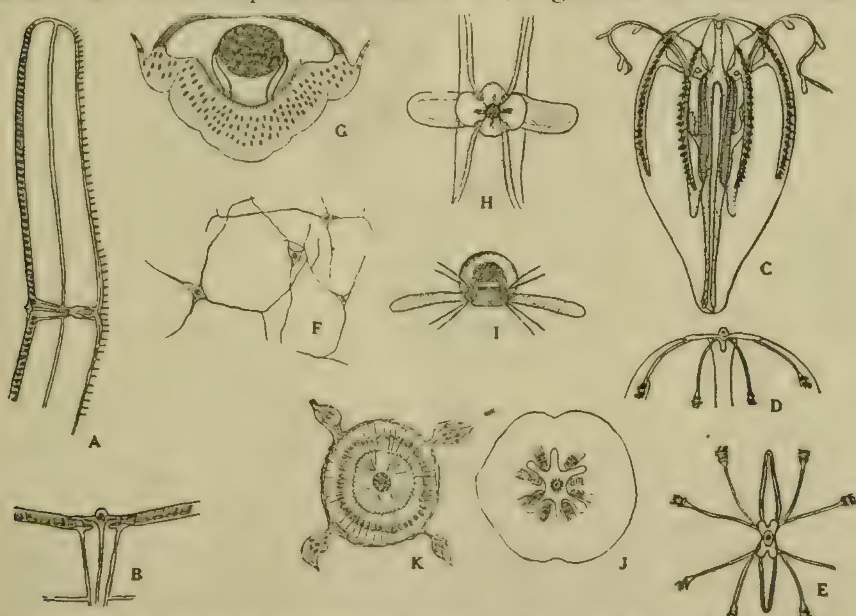


Fig. 7. Two-thirds of an elongate ctenophor, Mayer. B. Enlarged portion of sense organ of elongate ctenophore. C. Diagram of a ctenophore, Mayer. D. Sense organ of ctenophore from side showing connections with the eight ciliary glands. E. Same as D from above. F. Nerve plexus of a ctenophore, Hertwig. G. Apical sense organ of a ctenophore after Hertwig. H. Diagram of a ctenophore, Hertwig. H. and I. View of apical sense organ of a ctenophore showing its relation to the ciliary bands. H from the side, I from above. J. *Coenoplana* from above showing apical sense organ, Korotneff. K. *Coenoplana* sense organ in section with associated ganglia, Abbott.

I., J., from Parker and Haswell's Zoology, permission of Macmillan Co.

nervous system was by Hertwig, 1880. A subepithelial nerve plexus with the bipolar and multipolar cells has been described and figured. Bethe, '95, also describes and figures a network of nerve cells and fibers in ctenophores.

The characteristic aboral sense organ was first described by Edwards, 1841. At a later time Chun, 1878, describes and figures it in detail showing the little otocyst with its group of calcium crystals supported on four bands of fused cilia like a little table, with each tip of the leg coming into relation with two of the eight ciliary bands.

This peculiar balancing organ has been considered in a way to represent a central nervous system because of its reaction to the ciliary bands. These bands seem not to be under the control of the nerve cells and fibers, but some are of this opinion. The nervous system then would not relate to the cilia, but in some way there is a coördination of movement in the eight ciliary bands. That this is not as simple as might at first seem is shown by the fact that the effective stroke is in the opposite direction from the wave of ciliary action, so that the simple explanation of the movement of one cilium affecting the next, like a row of tenpins, does not hold.

Bauer, 1910, found by gently touching the mouth region of a ctenophore, that it stopped its cilia. If vigorously stimulated its plates vibrate more actively for a short time. If the aboral sense organ be removed the same reactions apply as before. He concludes from this that the reactions cannot be ascribed to the sense body but must depend upon the action of the diffuse nervous system which although chiefly concerned with the muscles of the cetenophore seems also to have an influence on the rows of swimming plates.

Göthlin in a recent paper, 1920, on the study of ciliary movements finds that the primary inhibition of the ciliary movement is probably due to cilio-inhibitory nerves. Receptors at the surface of the body transfer their impulses to the nerve-net. These in turn transmit them to the end apparatuses which inhibit the vibrations of the swimming plates, probably blocking the neuroid conduction between them. There is an intimate connection between primary and secondary inhibitory mechanisms. Both probably use the same receptors, but the primary mechanism functions on impulses of weaker intensity.

Abbott, 1904, who has studied the interesting worm-like *Coeloplana* has found a rudimentary nervous system with four ganglia symmetrically disposed about the otolithic capsule. Just outside the otolithic capsule in the angles formed by the intersecting tentacular and sagittal planes are four large nerve ganglia that send off fibers to form a sort of diffuse peripheral system and supply fibers that cover part of the capsule as an enveloping sheath. Each gang-

lion is opposite the point of insertion of the cilia which support the otolith. The cells of the nerve tracts and ganglia are large, triangular and stain deeply with methylene blue.

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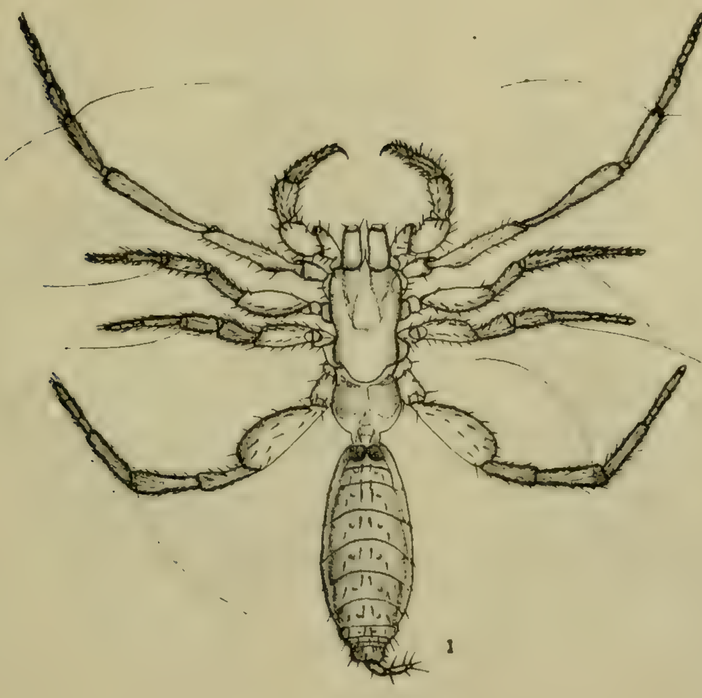
A List of California Arachnida

II. PEDIPALPIDA OR

WHIP-SCORPIONS

M. Moles

SCHIZONATIDAE. Eyes wanting, caudal appendage short, unsegmented or knob-like segment at end.



1

Trithyreus pentapeltis Cook. Found rather commonly about Claremont, Laguna Beach and farther south.

TARANTULIDAE. The tailless whip-scorpions. Eight eyes.

Acanthophrynus coronatus. May be nearly two inches long. Calif. possibly some specimens in the Pomona College collection may have some from the southern part of the state but no clear record.

Proc. Ent. Soc. V. 4, p. 249. Jour. Ent. Zool. V. 9, 1917, p. 1.

A List of California Archnida

A LIST OF CALIFORNIA ARACHNIDA

III. THE SCORPIONIDA

Fred A. Cox

Buthidae. Triangular sternum. One or two spurs on each side at base of last pair of legs. Three to five lateral eyes on each side. Hand of chelae rounded, fingers long. Usually a spine under the sting.

Uroplectes mexicanus. No spine under sting. Teeth on finger of palpus in many oblique rows. Texas and Calif.

Isometrus maculatus Linne. Santa Barbara and Catalina Islands. Slender long tail.

Tityus tenuimanus Bks. Buena Vista.

Centrurus californicus Wood. Lake Tule and Lake Co., Calif.

C. exilicaudus Wood. Lower Calif. and near San Diego.

Scorpionidae. Only one spur at base of last tarsal segment of last pair of legs.

Diplocentrus whitei. Texas and Calif. Twelve to eighteen teeth on comb.

CHACTIDAE. Only two lateral eyes on each side.

Broteas alleni Wood, length 1 to 1½ inches.

VEJOVIDAE. One spur each side of the base of the last tarsal segment of last pair of legs. Three lateral eyes on each side. Sternum usually broader than long. No spine under sting.

Uroctonus mordax Trorell. Dark colored, large claws. Common in Central and Northern Calif.

Anuroctonus phaeodactylus Wood. Rather hairy, red-brown. San Diego, Mojave Desert, Claremont. Common species.

Vejovis punctipalpi Wood. Red-brown, strongly ridged claw. Death Valley, San Diego Co.

V. hirsuticauda Bks. San Bernardino Co. Red-brown, 15 pectines. Length 1¼ inches.

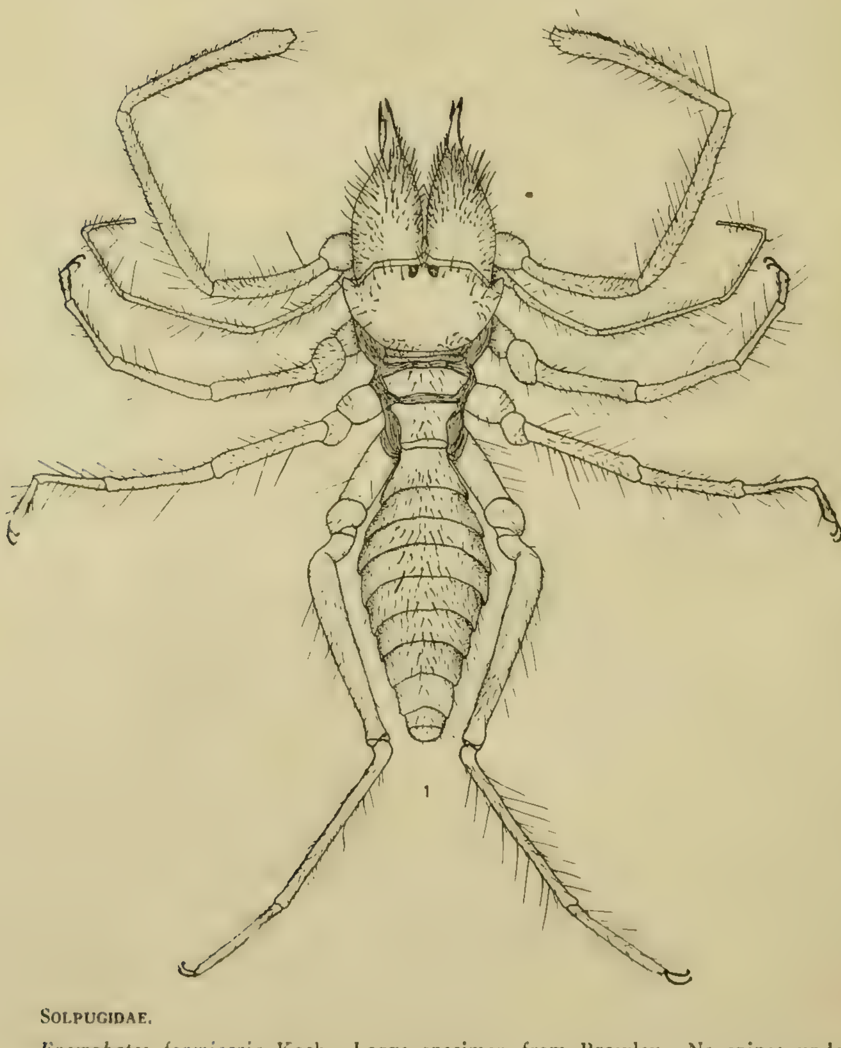
Hadurus hirsutus Wood. Deserts of S. Calif.

C. Jour. Ent. V. 2, 1910, p. 185. Ann. Mag. Nat. Hist. XVII, 1876, p. 11. Jour. Ac. Nat. Sc. Phila. 1863, pp. 387, 369, 372.

A List of California Arachnida

IV. SOLPUGIDA

J. Nesbet



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SOLPUGIDAE.

Eremobates formicaria Koch. Large specimen from Brawley. No spines under tibia in either sex.

E. californica Sim. From Laguna Beach and Calif. Movable finger of male constricted from below near apical third.

E. formidabilis Sim. Small spines under side tibia of palpus of male. Calif.

E. putnami. No spines on tibia of palpus of male. Calif.

Hemerotrecha californica Bks. Upper finger of chelicera wtih no teeth or many small teeth. Pacific Grove to Claremont.

Ammotrecha californica. Lower finger of chelicera fine teeth beyond large teeth at base. Broad dark band on middle of metatarsus of palpus. Calif.

Class des Galeodes 1879, p. 143. Ent. News 1903, p. 79. Jour. Ent. Zool. IX, p. 22. Proc. Acad. Nat. 1883: 3, p. 249.

Notes on Sense Organs in Some Asteroids

ARTHUR S. CAMPBELL

The sense organs of many species of starfish have been well studied during the past fifty years by a number of competent observers. Among the earlier important studies are those of Haeckel, 1860; Wilson, 1862, and Hamann, 1885. Later work, especially the more minute observations are the subjects of study of Cuénot, 1887, and of Pfeffer, 1901.

Materials for this study include most of the common littoral asteroids occurring at Laguna Beach. Representatives of six species, the members of three orders, were examined. All preparations were fixed in $HgCl_2$ and double stained, first in hematoxylin and then in picro-fuchsin.

Eyes are placed at the terminus of each ray, and just proximal and ventral to the terminal tentacle. In nearly all species they are well protected by a strong circlet of heavy spines. They are mostly of a deep red color which is slowly soluble in alcohol.

Viewed more closely the eye-spot appears as a pad in which there are a number of little depressions; these are the ocelli. Each presents a separate structure, the whole eye-spot being merely a composite of many ocelli. The number of ocelli varies greatly.

The histology of the ocelli in these forms has been disputed by several observers. Most of the earlier workers believed that lenses are present. Cuénot, 1887, does not accept this, but Pfeffer, 1901, indicates a lense in *Asteropectin mülleri.* In some of my preparations there is a little indication of an epithelial thickening bridging the eye-cavity, but mostly the eyes show a clear and rather wide, open space freely in communication with the exterior. These preparations indicate somewhat an intermediate condition between the two figures reproduced from Pfeffer.

Cells forming the eye are of two types. The several reproduced from Cuénot's paper, fig. 12, are pigment cells or sensory cells of the retina. They are surrounded and supported by cells of a second type; the so-called supportive cells of Cuénot and others.

The comparative structure of several eye preparations is figured. The supportive cells are well stained with fuchsin.

A sense organ in starfish was seen in *Linckia colombiæ* Grey, among my preparations in the course of this investigation. It is probably a tactile organ. It is seen in the ventral portion of the terminal tentacle, near the eye-spot. It consists of a number of papillæ extending over a restricted area of the tentacle. The papillæ are pronounced and have a similar structure to those found in other forms. They follow through a small series of sections rather completely, showing constant form. These may be like the so-called organs of taste described by Eimer, 1880.

(Contribution from the Zoological Laboratory of Pomona College)

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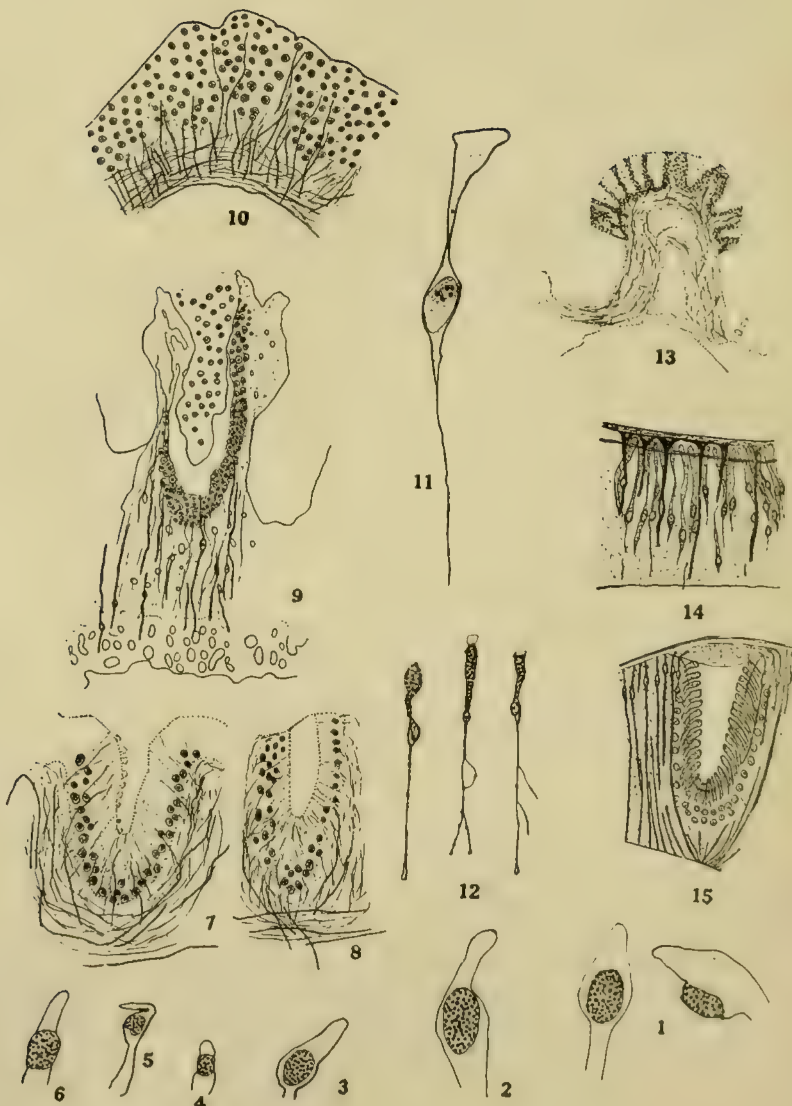
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V. Flatworms

TURBELLARIA. Among the turbellarian flatworms those of the Rhobdocoelida are the simplest. Böhming, 1890, describes and figures a number of central nervous systems from Alloeocoela such as shown in Fig. 8. The ganglia are somewhat concentrated but show right and left halves. Two or four pigment spots imbedded in the brain substance may show but little indication of differentiation into eyes.

Among the Acoela some have simple pigment spots for eyes and some are without them. Statocysts are found in the center of the ganglionic masses in some cases. Very often a well-marked statocyst or otocyst may be seen in the center of the upper portion of the animal, just between the pigment spots when they are present. The brain is not very extensive in Acoela. It is usually recognized as a small mass of cells surrounding the central statocyst. Löhner in *Polychoerus* gives about as complete account of the nervous system as any. There is a central ganglion with a central otocyst. Laterally there are two ganglia of nearly equal size. These ganglia in cross section are nearly central in position while the peripheral nervous system consists of longitudinal strands both dorsal, ventral and lateral in position. Figure 8 shows the plan of the nervous system as a whole.

De Quatrefages, 1884, and Peebles, 1915, and others give some indications of the nervous system and sense organs of these worms. but not much in detail.

Many investigators have dealt with the Rhabdocoela. The brain is a little more complex than that of the other groups mentioned but the whole system is compact and there are few longitudinal cords from the brain region.

Some forms have from two to four simple eyes imbedded in the brain. Sensory pits near the head end are found connected with the brain in some. Ott, '92, describes "dish-shaped" organs near the dorsal surface of the body of *Stenostoma*. In this form the ciliated pits are imbedded in the forward portions of the brain. In other forms, they seem to be entirely separate.

Schneider, '73, finds the lobes of the brain connected by a double commissure which surrounds the vascular system. Hallez, '79, Ott, '92, and others find but a single commissure.

The fibrous portion of the brain or "punkt substance" is composed of a fine network of fibers which some have thought was made up of anastomosing processes, but the evidence is not clear. Nansen, '87, does not believe in an anastomosis.

Some of the figures from the nervous systems of this group show few branches. Probably more branches were present although not recognized in every case by the investigators.

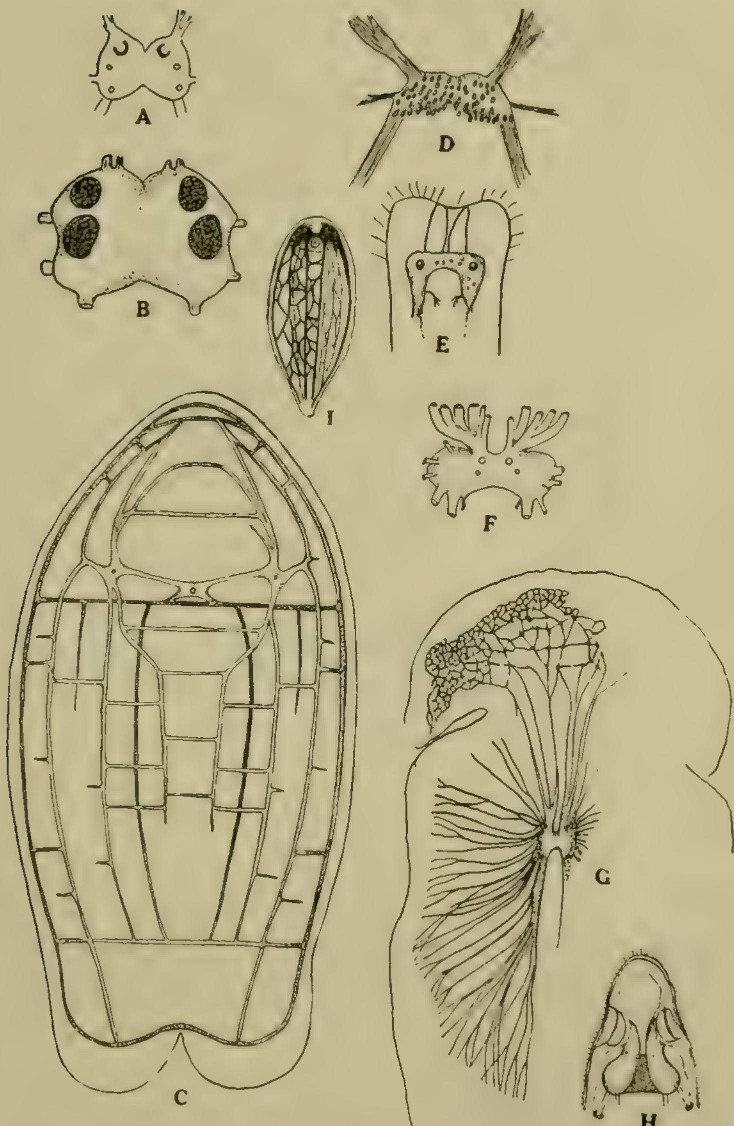

Fig. 8. NERVOUS SYSTEM OF RHABDOCOELIDA. A and B. Brain with one and two pairs of eyes of alloeocoelan flat worms, Böhming. C. Nervous system of an acoelan, *Polychoerus*, Löhner. D to H. Brains of Rhabdocoela. D. *Opistoma*. E. *Prorhynchus*, after Vejdovsky. F. *Gaffilla*, Böhming. G. Rhabdocoela nervous system, Böhming. H. *Stenostoma*, Ott. I. An acoelan showing nervous system after Böhming.

The brain consists of a rather broad flat mass of nerve fibers and cells occupying quite a large part of the forward portion of the head end. Many nerves run out to the surface of the body and two chief longitudinal strands run the length of the body. Usually a number of commissures connects the two parts of the brain as well as the two longitudinal strands. The number of these is somewhat variable in the different species and also in members of the same species. In some forms at least, terminal fibers connect peripheral branches at the margin of the body. Fig. 9, A, D, E. Usually two eyes are found connected with the brain by short nerves, but in some cases at least, such as in *Sorocelis*, as described in Seidl, 1911, there are neurone eyes scattered over the anterior region of the forward end.

Lateral extensions of the head end are often especially sensitive and provided with abundant nerve cells. The eyes, simple or complex have been well described and figured by Hesse, 1896. A sensory cell or cells with expanded ends terminate in a pigment cup which aids in centering the light on the protoplasmic ends of the sense cells. Fig. 9 F-H.

Very little has been done in analyzing the motor and sensory components of the brain and nerves. Branches to the eyes and to the surface of the body, especially the forward end of the body, are undoubtedly sensory in nature. The brain has been divided by some into an anterior and superior sensory region and a posterior and inferior motor portion. Some of the chief works on this group are by Chichkoff, '92; Iijoma, '84; Lang, '81; Woodworth, '91; Wheeler, '94; Vejdovsky, '95; Hesse, '97; Micoletzky, 1907; Weiss, 1910; Seidl, 1911.

Rina Monti, 1896, has studied the nerve terminations in the skin of fresh-water planarians.

The Polycladida are usually considered as having a more complex nervous system than the tricladids, but it is more concentrated. As a rule there is a number of simple eyes scattered over the forward end of the body such as shown by De Quatrefages, 1844, although in *Planocera* Lang, '82, shows rather concentrated eye areas. In *Leptoplana*, the eye spots are scattered about in the region of the nervous system, as shown by Schmidt as early as 1862.

Although locomotion in planarian worms may in part be by the surface cilia, the chief activities seem to be by means of muscles of the body under the control of the nervous system. Weak chemical or tactile stimuli cause them to react positively. The resting worm responds less readily than the moving one. Some forms with much more highly organized eyes react less well than others with simpler eye spots. As a rule strength of light is less important in reactions than the number of sensory elements in the eye, or the former

habits and experiences of the animal. Headless forms respond to light but less quickly. As a rule if the head and eyes of a planarian are removed the headless portion reacts as before but much more slowly. In marine flatworms where the ganglia are more concentrated in the head region and where there are fewer ganglion cells along the lateral cords, the activities of the headless worms are much less perfect than in planarian worms of fresh water.

In the flatworms special cells of the ectoderm give rise to the head ganglia. Later stages, or the development of the peipheral system have been but little studied.

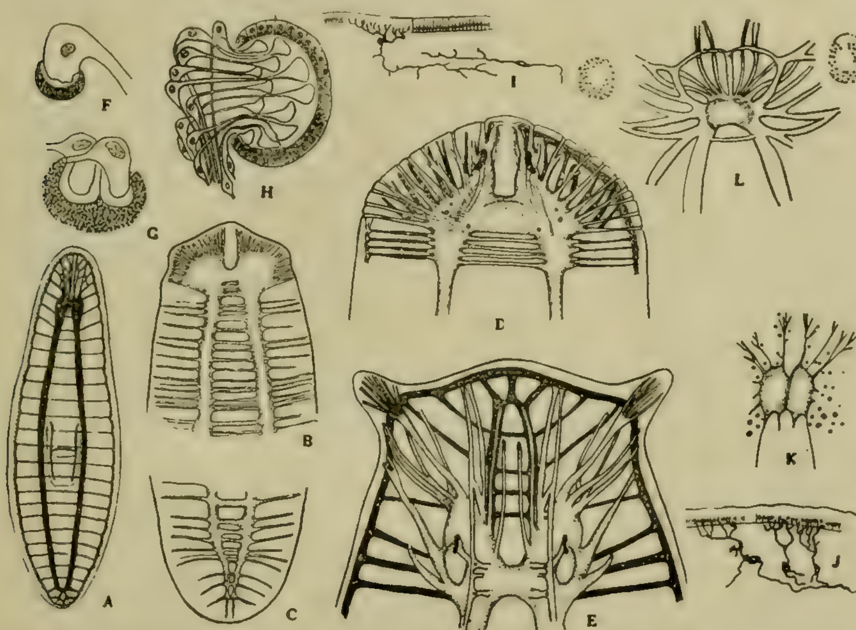

Fig. 9. NERVOUS SYSTEM OF POLYCLAD AND TRICLAD WORMS. A. *Snycoelidium*, Wheeler. B, C. Head and tail ends of *Sorocelis*, Seidl. D. Brain and head end of *Planaria bohmegi*, Weiss. E. *Planaria apina*, Micholetzky. F and H. Eyes of Planarians, Hesse. I, J. Nerve endings in skin Planarians after Monti. K. Brain and eyes of *Leptoplana*, Schmidt. L. Nervous system and eyes polycladid, Lang.

Kepner and Rich, 1918, have studied the reactions of the proboscis of flatworms. In accordance with Monti, '97, and Steiner, '98, they found that the ventral nerves are ganglionic and these centers exercise control over the posterior parts of the body. The middle branch from each of these ventral nerve trunks leaves the ganglion that lies nearest the base of the proboscis and from here enters it. When the proboscis is removed from the animal it undergoes autoamputation. Without the control of the adjacent

ganglia the proboscis in this way acts as a reflex organism. The freed proboscis is able to carry out the three usual coördinated muscular movements when the muscles are intact. The free proboscis cannot determine food from other substances. The central nervous system is necessary for this.

The eyes of turbellarians have been extensively studied by Hesse, '96. In tricladids they consist of visual cells and pigment or acsessory cells. These last inclose the enlarged ends of the visual cells, the rhabdomes. The number of visual cells or retinulæ as well as the accessory or pigment cells differs greatly. Kepner and Taliaferro, '16, found the retinulæ to consist of three regions; a lateral nucleus bearing region closely applied to the brain with a nerve fiber extending into it, a middle region lens shaped, homogeneous and highly refractive, and the true rhabdome in the pigment cup. Kepner and Foshee, '17, compare the three regions of the retinula with the rods and cones of vertebrates. The parts show a close analogy if not homology with the myoid, ellipsoid and rhabdome. The retinulæ of both flatworms and vertebrates are also of the inverted type. Taliaferro, 1920, has an important paper on the reactions of Planaria to light. The species considered was negative to light and turned itself accurately to horizontal rays. In some cases the reactions were direct, they turned away at once without preliminary movements. Specimens with both eyes removed do not react exactly as normal individuals, but they do move in general away from light. The rate of locomotion in these is not appreciably affected, but the removal of the anterior end greatly retards the rate of locomotion. Specimens with one eye removed orient themselves accurately to light when illuminated on the normal side, but do not when stimulated in this way on the blind side.

According to Taliaferro, light must strike a given rhabdome parallel with its longitudinal axis in order to cause stimulation. "Thus, the position of the longitudinal axis of the rhabdome results in a localization of photic stimulation." It is possible, according to this investigator, to explain the localization of photic stimulation in one of two ways. First, the refractive central region of the retinula acts as a sort of lens to concentrate the light on the sensitive rhabdome. Second, by assuming a certain structure of the rhabdome coupled with a shading action of the pigment-cup. Hesse, '97, ascribes the localization of the stimulus entirely to the pigment-cup.

TREMATODA. In monogenetic forms such as *Tristomum* Lang, 1881, or *Epidella*, Heath, 1902, the brain consists of a rather short, semicircular band near the dorsal surface just in front of the pharynx. From it six longitudinal nerves arise, four ventral and two dorsal. These extend the length of the body and end in the posterior sucker. Many small nerves spring from the brain and the six

longitudinal cords. A short distance from the brain the anterior nerves are united into a curved ganglion and from this a number of branches run to the anterior end of the body. On the mid-dorsal line a small median nerve in *Epidella* runs towards the head and towards the sucker, but was not found farther than this.

In the main nerve strands and ganglionic areas bipolar cells are of frequent occurrence and generally one branch from each might be traced close to the surface of the body while the other fiber passes into the brain. In a few cases the fibers pass to the opposite side of the ganglion or brain before they terminate. Cells with three branches in *Epidella* were found with one process to the

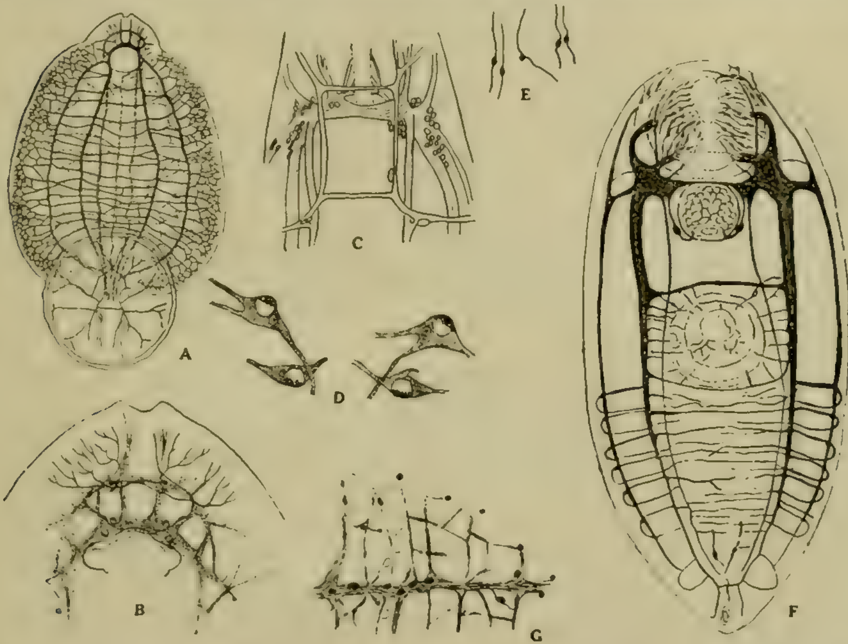

Fig. 10. TREMATODE WORMS. A, B, D, Monogenetic forms. C, E, F. G, Digenetic. A. Nervous system *Tristomum*. B. Head end of ***Epidella***, Health. D. Eyes of Epidella, Health. C. *Amphistomum*, Loos. E. Sensory cells of trematode, Havest. F. Nervous system of *Cercarioenum*, Bettendorf. G. Nerve plexus *Corcoriaenum*, Bettendorf.

brain, another to the substance of the sucker of the same side, and the other crosses over to the sucker of the opposite side.

In *Epidella*, the large mass of nerve fibers and the more numerous longitudinal bands on the ventral side are explained by the fact that this side rests against the host.

There are four eyes in *Epidella*. In other forms they seem not

always as well developed and may not always be functional. In this form the eyes appear as four small pigment spots partly imbedded in the dorsal surface of the brain. In this and in *Tristomum*, each eye-spot consists of an almost spherical, highly refractive transparent body which in many cases contains one or two small vacuoles, but a nucleus was not seen. The lens is partly covered by a cup of dark brown pigment granules. These parts are imbedded in a rather large ganglion cell. Two or three fibers arise from each ganglion cell and extend some distance into the brain. A series of delicate muscles are near the eyes and their contractions bring about rotations of the eyes. One pair of eyes has been found to move simultaneously with the other, although this does not always take place. If the animals are vigorous the movements of the eyes may take place with the rapidity of a heart beat.

The eyes are situated on the dorsal side of the brain. The tissue between them and the ventral side is clear and light passing under the host must strike the lens and affect the retina as the pigment is placed in the most favorable position in the anterior side of the lens.

In some digenetic trematodes the nervous system has a rather complicated system of branching as shown in *Amphistomum* by Loss, 1892. Nerve tracts are clearly defined and nerve cells, although chiefly centered in the broad brain, are also found out along the peripheral nerves.

Faust, 1918, has studied the eyes in digenetic trematodes. In twenty-eight species, seven possess pigmented eyes and four non-pigmented ones. Binoculate species usually have the eye spots in direct connection with the posterior dorsal nerve trunks. In one at least connections were with the anterior dorsal rami. The central eye of trioculate species is fused to the anterior dorsal nerve trunk by a blunt fiber from below. The eye spots consist of a cluster of rather dark-brown granules forming a deep cup. Within the cup is a spherical body barely touching the pigment granules. This is the enlarged nerve ending with a nucleus within.

The development of the eyes in *Cercaria gigas* is as follows:

A branch of the posterior dorsal nerve with a single nucleus pushes out from the nerve center to the dorsal margin of the embryo. As it reaches a position near the surface, the ectodermal layer of the embryo pushes inwards just posterior to the nerve, so that a pocket is formed with the opening opposed to the nerve cell. The end of the nerve fiber enlarges and twists about the inner wall of the pocket so that the end with the nucleus comes to lie within the cup. At first the ectodermal cells are evident, but later they disappear. Pigment granules are not present until the nerve ending comes to occupy its position within the pocket. Golden-brown pigment granules come to be formed between the nerve endings and the

ectodermal cup. The cell within the cup enlarges and becomes the lens. The lens is in this way derived from the nerve center.

In *Cercariaenum* Bettendorf, 1897, shows six longitudinal strands from the brain, with many branches to the pharynx and the suckers. A complex nerve plexus of nerve fibers and nerve cells is found over much of the body. Especially are bipolar sense cells found in the pharynx. Similar bipolar sense cells are demonstrated by Havet, 1900, by the Golgi method.

CESTODA. The scolex contains the greatest concentration of the nervous system although in *Gryocotyle* there is fully as great a

Fig. 12. The sketch at the top is from a section across a young flatworm showing the brain as a dark mass in the left side. The figure at the left below is from a larval flatworm showing the position of twelve simple eyes. The middle and lower left hand figures are from embryonic stages of a nemertinian worm showing the developing nervous system on the left and shown darker in the figures. Salensky.

mass of central nervous system in the caudal end of the animal. The suckers or other appendages of the scolex region are supplied with special branches. In some forms there is a definite ring of fibers. In all two larger and usually four smaller longitudinal strands run the length of the animal.

Blanchard, 1847, dissected the nervous system in *Ligula* where he found a mass of nervous tissue in the scolex with strands run-

ning through the body, especially two thick ones. Moniez, 1881, found the commissures in the forward end of the body.

Lang, 1879-82, figures and describes the nervous system of a member of the Cestoda where he finds a concentration in the scolex region and nerves running from this center to the appendages in this region when present and also long nerves which run the length of the body.

Roboz, 1882, shows the central ganglion and an extensive nerve network in cestodes. Some authors claim to have seen ganglion cells along the nerve strands and in fact Kahne considers the chief longitudinal strands as central organs.

Haman, 1885, also describes the long nerve fibers as having ganglion cells on them.

Niemeic, 1886, in *Ligula* shows a central ganglionic mass with two thick strands leading from it and four or more smaller ones, some of which branch again. Blanchard found similar conditions.

In *Schlistocephalus*, Moniez gives a brief description of the nervous system also Niemiec, 1886.

In *Bothriocephalus*, Niemiec gives some indications of commissures in the scolex region.

In *Taenia*, Blanchard gives some indication and Moniez distinguishes a nerve ring in the tip of the scolex. Blumberg, 1877, finds a larger number of longitudinal nerves than the last author and Nitsche finds ten strands from the neck region of *Taenia*.

Niemiec, 1886, finds a nerve ring in the rostellum and eight nerves coming from the ring. As each one leaves there is a swelling on the ring with small ganglion cells. A commissure surrounds the central ganglion. Other commissures were also found in this region.

In *Acanthobothrium* Pintner, 1881, was one of the first to describe the nervous system. Niemiec shows it with branches to the forward region, a ring commissure below the main ganglion and with two thick and other thinner longitudinal strands.

In *Tetrarhynchus* Lang, '82, was one of the early students. Figure 11-L, is from another species which resembles the condition in *Tetrarhynchus*.

The nerve cells of Cestoda differ greatly in size. Niemiec gives figures from the cells and nuclei of a number of species. He finds them to be from 12 x 16 microns to 28 x 34 microns cell body; nucleus, 5 x 8 microns to 9 x 13 microns.

Among the more recent literature is the work of Tower, 1900, on *Moniezia*. The complicated nervous system of this species is shown in Fig. 11, A.

Kofoid and Watson, 1910, call attention to the similarity of the nervous structures in the scolex of cestodes with that of the posterior region of some trematodes, and they suggest that with *Gyrocotyle* as an intermediate type the scolex part of the nervous system of tape worms represents the caudal end of the worm.

The only sense organs of tape worms are represented by very simple end knobs of sense cells in the cuticle. Fig. 11, B.

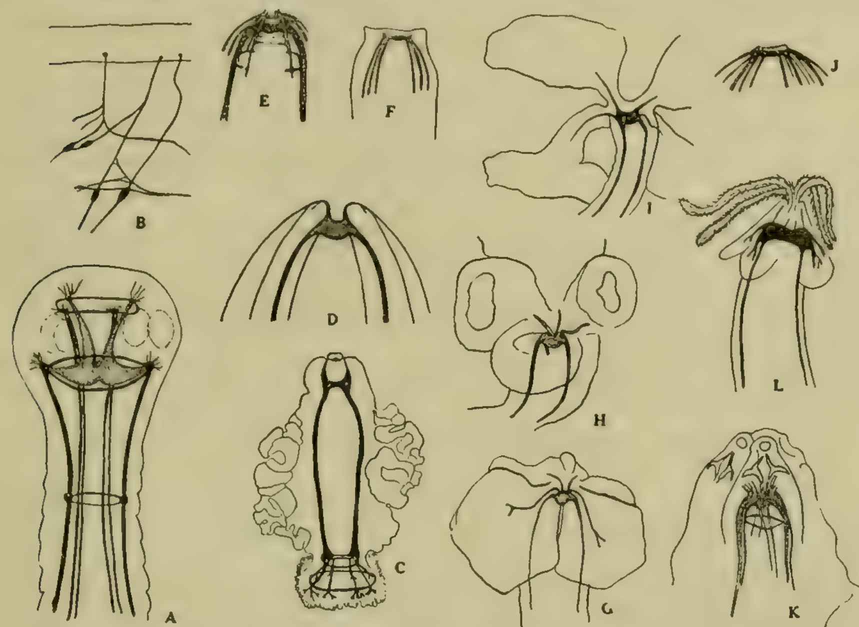

Fig. 11. NERVOUS SYSTEM CESTODA. A. Moniezia, Tower. B. Sensory cells ending in hypodermis, Zernecke. C. Nervous system *Gyrocotyle*, Kofoid and Watson. D, E, F, G, H, I, J, K. Central nervous systems scolex end several species of Cestodes. L. *Rhynchobothrium*, Lang.

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A List of California Arachnida

V. PHALANGIDA OR HARVEST MEN

L. Myers

First three figures from Banks.

COSMETIDAE. Second pair of legs without endites. Pediplalps shorter than the body. Eye tubercles low.

Cynorta bimaculata Bks. San Diego. No spines or tubercles at caudal end of the body.

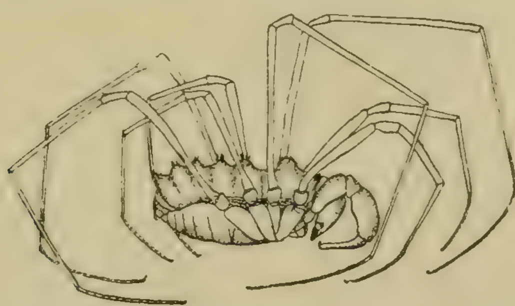
PHALANGODIDAE. Hind coxae united to first abdominal at base, free at apex. Second pair of legs distinct endites. Pediplalps large. Spiracles indistinct.

Sitalces californicus Bks. Martin Co. and Mt. Shasta.

Sclerobunus robustus Pack. Mt. Shasta region.

Scotolemon californica Bks. Alabaster Cave, Calif.

PHALANGIIDAE. Last segment of the pedipalps long and armed with a claw. Coxa of fourth leg is united near its base on the posterior side to the tracheal sternite of the abdomen. Tibial spiracles are present.



Protolophus tuberculatus Bks. Gray to brown, more or less mottled. Abdomen often red-brown. Claremont, Santa Catalina, Santa Rosa.

P. singularis Bks. Near San Diego.

Mitopus californicus Bks. Los Angeles. Gray above, mottled, femora and tibia brown.

Globipes spinulatus Bks. Red-brown, base of legs yellowish. Eye tubercle low. S. Calif.

Leptobrunus californicus Bks. Whitish above, mottled with brown and black. Indefinite vase mark. Los Angeles and S. Calif.

Eurybunus brunneus Bks. Body very smooth; fourth leg nearly as long as second. S. Calif.

E. spinosus Bks. Gray above, black mark on each side of base of abdomen. Femora I and III brown, with a pale ring on middle.

Leiobunum bimaculatum Bks. Dark brown, two prominent yellow spots. Near San Diego.

L. exilipes Wood. Female dark rose mark on dorsal side. From N. Calif. to Claremont. Common in mts. near Claremont.

ISCHYROPSALIDAE. Last segment of pedipalps shorter than next to last, without claw. Coxa of fourth leg not fused with adjacent sternite of abdomen. No tibial spiracles.

Taracus spinosus Bks. Pale yellow, claw of mandibles red-brown. S. Calif.

T. pallipes Bks. Mt. Shasta.

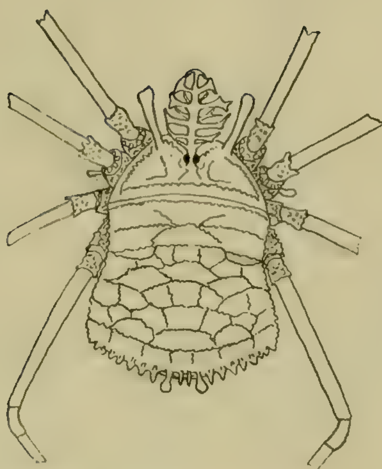
NEMASTOMATIDAE. Stermites of abdomen free, overlapping, and without median divisional sulcus. The first and second abdominal stermites narrowed in front and extended betwen coxae.

Nemastoma modesta Bks. Back brown to red-brown. Legs pale. From eye tubercle backwards a row of tubercles, flat tops broader than base. Mt. Shasta, Claremont.

TROGULIDAE. Stermites of abdomen except genital and anal, fused, do not overlap. They have a median longitudinal sulcus. The first and second abdominal sternites widely rounded in front and overlap the proximal parts of the two posterior pairs of coxae.

Ortholasma pictipes Bks. Eye tubercle. Four to five openings on a side. Humbolt Co. and Mt. Wilson.

O. rugosa Bks. Common in S. Calif.



Dendrolasma mirabilis Bks. Coulterville, Calif.
Pomona Jour. Ent. 1911, p. 412. Bull. Ill Nat. Hist. 1889 N. 3, p. 99.

Figure above, *Leiobunum bimaculatum*. Below, *Protolophus tuberculatus*. Figure at the right, body of *Ortholasma pictipes*.

A List of California Arachnida

VI. ACARINA OR THE MITES AND TICKS

F. Cox, P. Jahraus, W. Moore

Figures from Hall, except the plate.

EUPODIDAE. Body divided into cephalothorax and abdomen. Palpi without thumb. Beak small. Eyes when present near posterior edge of the cephalothorax. Body soft. Moderate to very long legs. Palpi short. Mandibles small but chelate. Mostly on ground, predaceous.

Eupodes brevipes Bks. Body red, legs clear. Slender. Sides concave. Laguna Beach.

Rhagidia pallida Bks. Under stones, Claremont.

Penthaleus bicolor Bks. Spherical, dark body, red legs. Common Claremont.

BDELLIDAE. Snout mites. Skin not hard. Palpi 4-5 segments. Cephalothorax large, well separated from abdomen. Palpi large geniculate and bearing long tactile bristles. Mandibles chelate. Body elongate. Lives in moss, dead laves, etc. Predaceous.

Bdella peregrina Bks. Claremont, Chino.

B. lata Ewing. On live-oak, under stones, etc. Claremont.

B. californica Bks. Body white, legs, palpi yellowish beyond base. Body narrowed in front to beak. Eye each side cephalothorax, four hairs in front, longer one each side beyond eye. Abdomen a few short hairs above. Legs rather slender. Clarmont.

B. utilis Bks. from black scale.

ANYSTIDAE. Coxae contiguous, radiate. Legs slender, bristly. Body few hairs. No dorsal grove. Tarsi not swollen.

Erythraeus posticatus Bks. Palpi slender, a long thumb. Body dark red, legs pale. From bark of eucalyptus, Claremont.

E. augustipes Bks. Under stones, Claremont.

E. hiltoni Bks. Claremont.

Erythaeus sp. not mature, on phalangid, Palmer's canyon near Claremont and on horned toad Laguna Beach.

Tarsotomus terminalis Bks. Body slightly constricted in middle. Two eye spots in cephalothorax. Many long erect bristles. Claremont.

T. macropalpis Bks. Large species sparce bristles, body nearly twice as long as broad. Claremont.

TETRANYCHIDAE "Red spiders". "Palpus with thumb, body well clothed with hairs. Legs I and II without spine-like processes. Coxae not radiate. Legs usually in groups of two each. No dorsal grove on cephalothorax. Tarsi not swollen. Mandibles for piercing. Hair on body usually in four longitudinal rows. Body oval, few bristles. Suture between second and third pair of legs. Red, two to four eyes. Pedipalps four jointed, usually a strong claw on next to last joint.

Tetranychus simplex Bks. Date palm, El Centro.

T. mytilaspidis Riley. S. California on orange. This is the "citrus red-spider". Red in color, bristles arise from tubercles.

T. sexmaculatus Riley. In San Diego Co. in colonies in depressions covered with silk.

T. bimaculatus Harvey. On fruit trees, and food plants. Common on many plants.

Tetranychoides californicus Bks. On citrus trees.

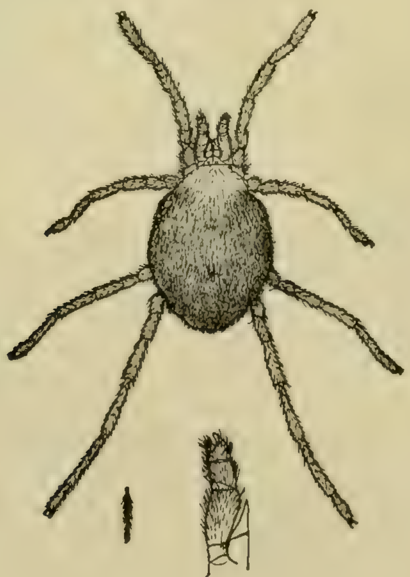
Tenuipalpus californicus Bks. Small flat, sometimes on citrus trees. Little damage.

Caligonus terminalis Bks. Red body. Chula Vista, San Diego. On lemon leaves, not abundant or important.

Bryobia pratensis Garman. In East called clover mite. In Calif. called almond mite. S. Calif. and north. Long front legs, four scale-like projections on front margin.

RHYCHOLOPHORIDAE. Skin not horny. Cephalothorax without special hairs. Legs in two groups. Palpi with last segment a thumb, while next to last ends in a claw. Cephalothorax large on same plane with abdomen, dorsal groove present.

Rhyncholophus moestus Bks. Red. Monrovia.



R. arenicola Hall. Bright red or straw color. Dry sand Laguna Beach.

R. gracilipes Bks. Santa Rosa I.

TROMBIDIIDAE. Harvest mites. Palpi geniculate, ending in one or two claws and with a thumb at the end. Coxae in groups. Body thickly dotted with short hairs, tarsi often swollen. Cephalothorax small and almost completely hidden by the projection of the anterior part of the abdomen. Mandibles for biting. Body globular

or elongate, red, hairy, usually transverse suture between seiond and third lgs. Eyes often stalked. Legs with two claws. Larva three pairs of legs. Parasitis on spiders, flies, etc.

Trombidium perscabrum Bls. Red, length 1.4 mm. Peculiar knobbed hairs. Claremont, also fresh-water pool Laguna Beach.

T. claremonti Bks. Evey's canyon near Claremont.

T. parificum Bks. Dark red. From ants' nests, and from Evey's canyon.

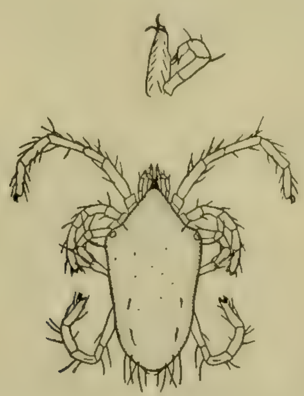
Trombidium sp. Near Camp Baldy.

HYDRACHNIDAE. Fresh-water mites. Mouth-parts not in a beak. Usually suckers near genital openings. One or two pairs of eyes. Body oval or spherical, sometimes of large size, often bright colored. Legs usually five-jointed with swimming hairs. Often attached to aquatic insects.

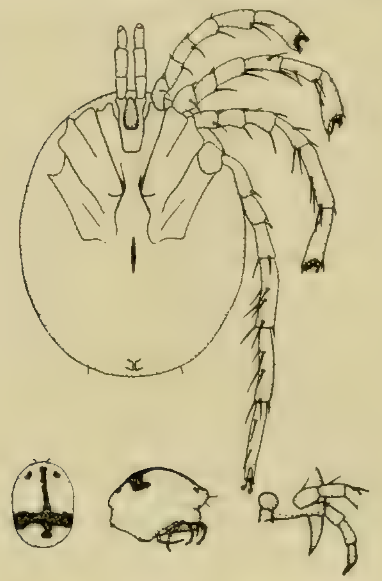
Hydrachnid. Larvæ on notonectid, Claremont, on carabid beetle Laguna Beach.

Hydracna sp. "Probably new" Banks. Large dark red-brown, spherical, found in great abundance at Laguna Lakes July and August, 1915.

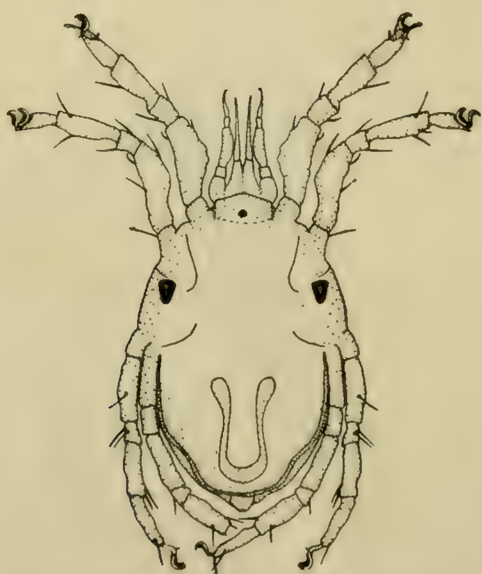
HALACARIDAE Salt-water mites. Body rather elongate. Usually a suture between the second pair of legs. Rostrum often large. Usually three eyes. No swimming hairs on legs. Mouth in a distance back, no ventral suckers. Lives upon algae.



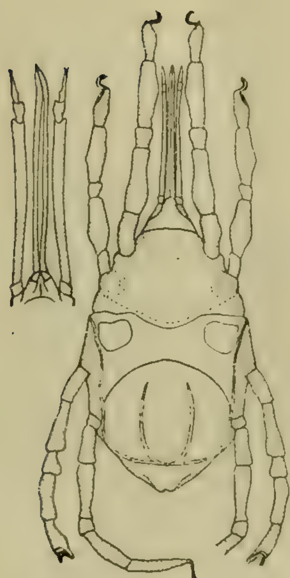
Pontacaraus californicus Hall. Under stones low tide.



Pontarachna cruciata Hall. Body highly arched globular. Laguna Beach tide pools.



Copidognathus curtus Hall. Tide pool Laguna Beach.



C. californicus Hall. Tide pool Laguna Beach.

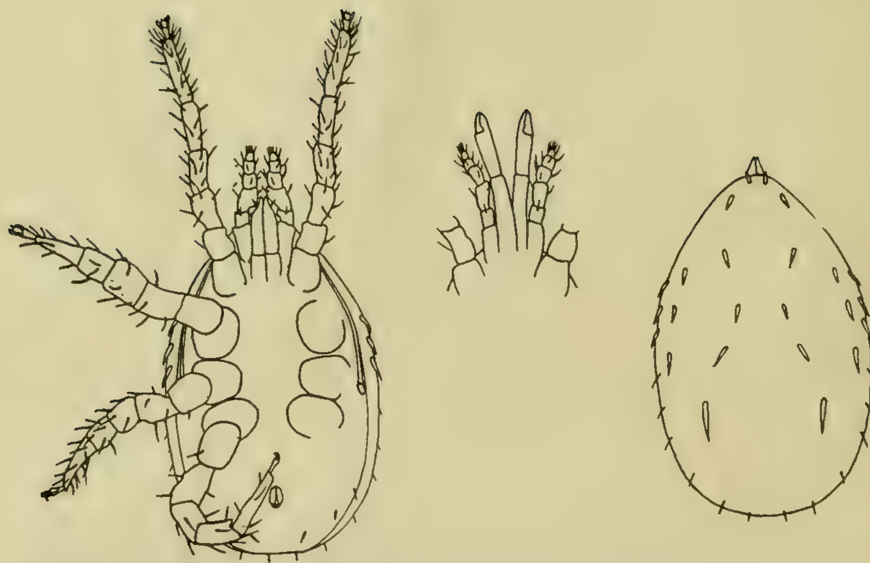
GAMASIDAE. Scavenger mites, body broad, short legs, no eyes. Mandibles usually chelate. Pedipalps five-jointed, legs six-jointed ending in two claws. First pair of legs inserted at one side of the mouth opening. Male genital opening usually on anterior margin of sternal plate.

Gamasus californicus Bks. Body yellowish, legs paler.

Parasitus frontalis Bks. From wild mouse, Laguna Beach.

Parasitus sp. Free living, Claremont, Chino.

Macrocheles sp. Chino swamp.



Seius orchestoideae Hall. Female light straw color. Male lighter. Dorsal plate over whole back. Ovoid. From the amphipod *Orchestoidea californiana*, Laguna Beach.

Laelaps pilosula Bks. Santa Rosa I.

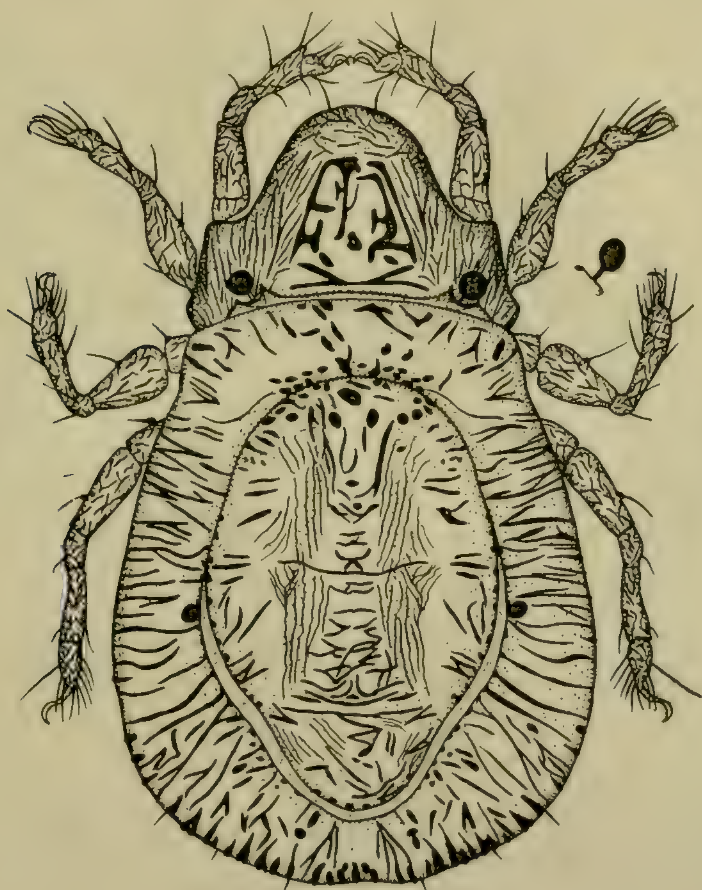
UROPODIDAE. With a distinct spiracle on lateral stigmal plate above 3-4 coxae. First pair of legs inserted in same opening as mouth-parts. Back of body extending towards and hiding mouth-parts from above.

Uropoda sp. Young on carabid beetle and on *Scolopendra.*

DERMANYSSIDAE. Mandibles for piercing. Body sometimes constricted. Parasitic on vertebrates.

Dermanyssus gallinae Redi. Parasitic on chickens.

ORBATIDAE. Horny beetle mites. Cephalothorax with a special hair on the posterior lateral vertex. Skin hard. Abdomen wtih wing-like expansions. Body minute, divided into two parts by transverse suture. Mouth-parts small hidden. Live upon vegetable or decaying material. Palpi five-jointed.



Hermannia hieroglyphica Hall. Brown, black markings, mandible chelate. Rough deep sculpturing. Claremont.

Oribata humida Hall. Color chestnut, polished. Abdomen with wings. Mandible chelate. Laguna Beach under board.

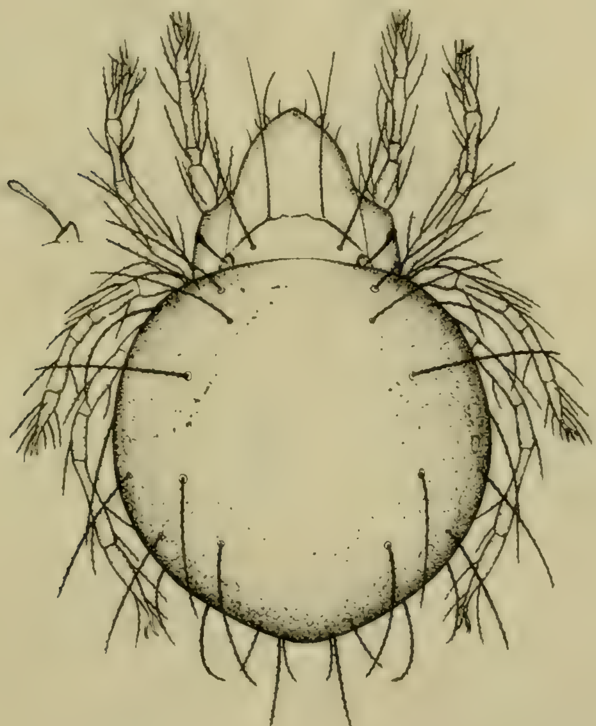
O. californica Bks. Abdomen red-brown, basal joints of legs brown, rest yellowish-brown. Cephalothorax brown. Mt. Shasta.

O. alata var. *californica* Hall. Black, polished abdomen with wings. Claremont.

Phthiracarus cryptopus Bks. Body brown, yellowish at base of abdomen. Smooth shiny, legs pale. Cephalothorax six bristles above, anterior pair shorter than others. Abdomen large high, about one-fourth longer than broad, two rows of fine hairs each side above. Legs very short and hairy. Claremont.

Eremaeus bilamellatus Hall. Claremont under leaves.

E. modestus Bks. Trunk and branches orange trees. Live upon plant life growing on trees.



Notaspis pectinata Hall. Yellow brown, smooth, polished. Claremont, Calif.

N. bilamellatus Hall. Light chestnut, smooth not polished, without wings. Mandibles large chelate. Follows Michael, near *N. burrowsi*, but differs in having no hairs on abdomen. Under stones Claremont.

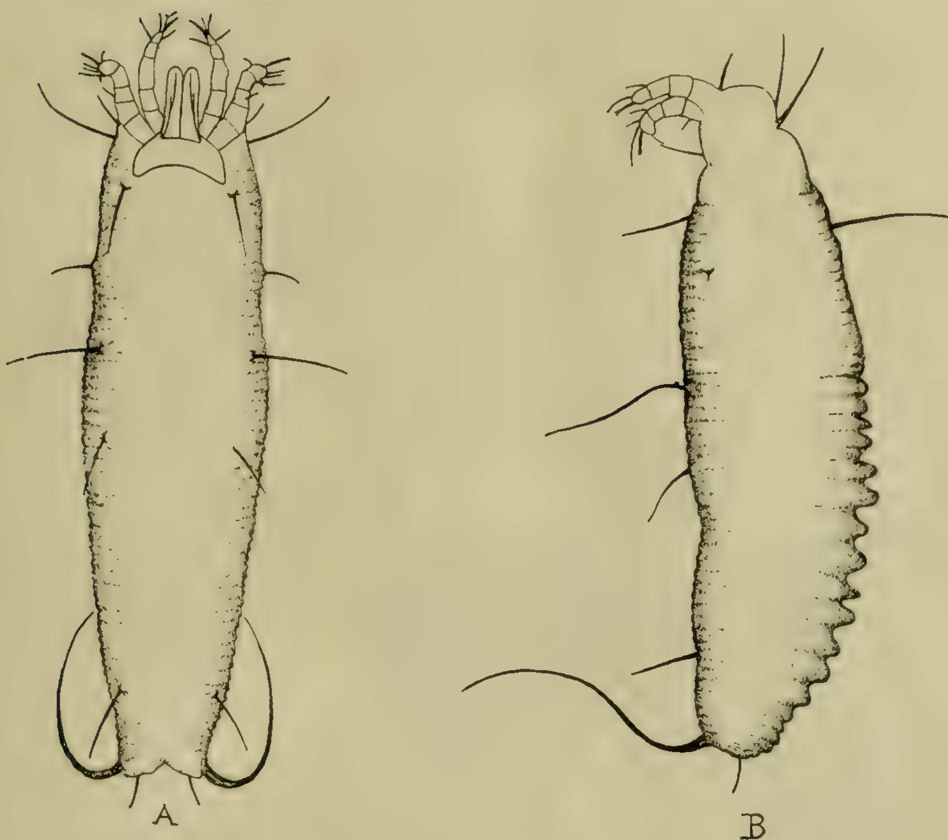
N. nuda Hall. Black, smooth polished. Mandibles chelate. Under boards, Claremont.

Paraliodes incurvata Hall. Dark brown, almost black, stout chelate.

Lohmannia spinosa Hall. Legs colorless, skin clear. Mandibles heavy chelate.

Liacarus modestus Bks. Body pale, red-brown, legs pale yellow. Cephalothorax four ridges, and four bristles above.

ERIOPHYIDAE Gall mites. Body small, worm-like caudal end elongate. No eyes. Two pairs of legs. Galls always open.



Paraphytoptus californicus Hall. (Possibly may be *P. peravorus.*) Gall on *Artemisia.* Abdomen anulate.

Eriophyes oleivorus Ash. Silver mite.

Tarsonemidae. No ventral suckers. Legs end in claws, body divided into cephalothorax and abdomen. Female with clavate hairs between legs one and two.

Tarsonemus approximatus Bks. Pomona, Calif. Under *Citricola* scale.

T. assimilis Bks. From red scale. Whittier.

Tyroglyphidae. Small, elongate, smooth. Legs alike. Chelate mandibles, no eyes. Palpi close against mouth parts. Legs long, clavate hair on tarsi of one and two. Not parasitic except a few on bees. Mostly live on organic matter. Cheese mites, etc.

Tyroglyphus longior Gervais. Hairy bristles on body, long tarsi. Calif.

T. americanus Bks. From lemons in storage S. Calif.

Trichotarsus xylocopae Donn. European species found on *Xylocopa californica.*

Rhizoglyphus longistriatus var. *californicus* Hall. From Banning, injury to bark of apple tree.

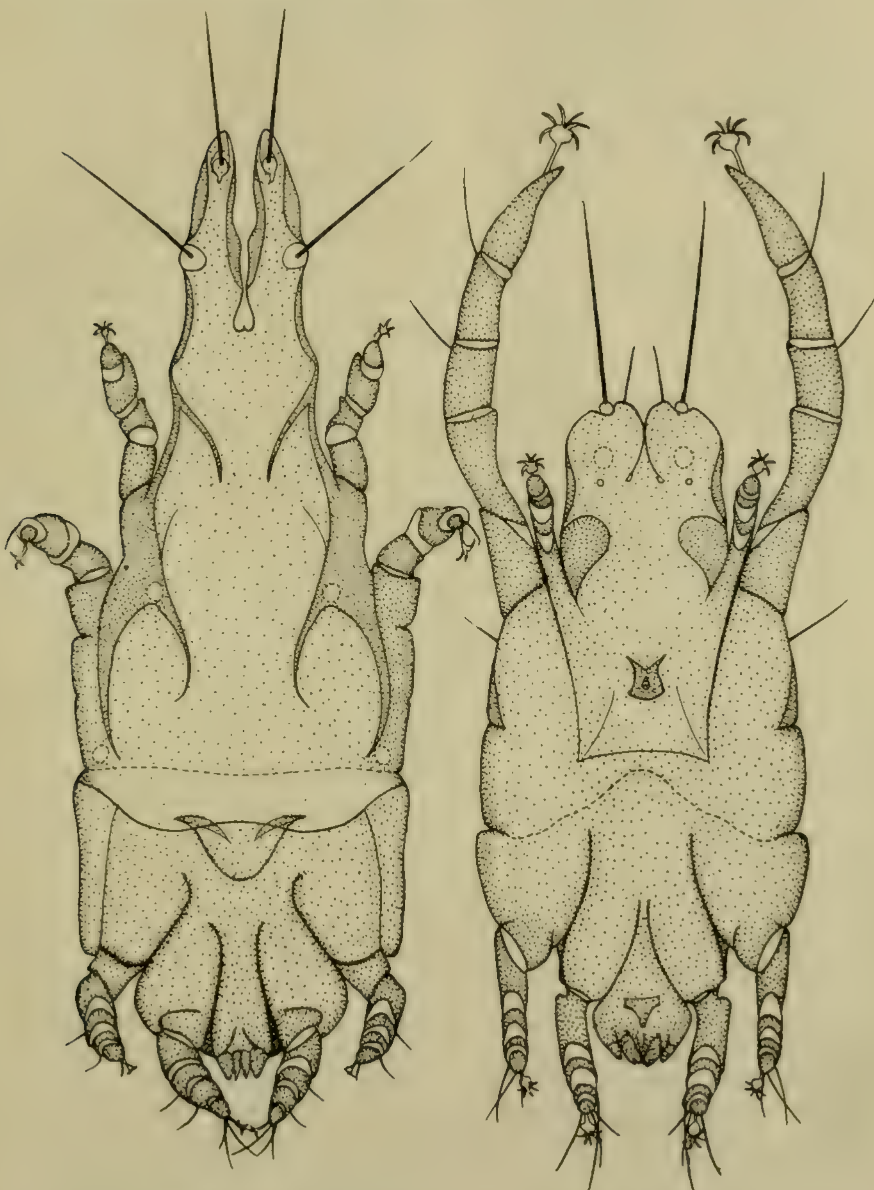
R. tarsalis Bks. Spreckels, Calif., on sugar beet.

R. rhizophagus Bks. On onions, Calif.

Glyciphagus obesus Bks. Berkeley, Calif.

Carpoglyphus passularum Hering. From Fresno on dry figs.

ANALGESTIDAE Bird mites. Small, elongate, transverse striations on the body.



Pteronyssus bifurcatus Hall. Integument strongly chitinized, from *Peterochelidon lunifrons.*

THE TICKS

ARGESIDAE. No dorsal shield, head hidden under front of body. Skin rough coxae usually contiguous or nearly so. Tarsi without apical pulvillum.

Argas miniatus Koch. Riverside.

Ornithodoros coriaceus Koch. San Francisco and Santa Clara Co.

O. megnini Dug. Red brown to black. Los Angeles.

O. talaje Guer. San Clemente Island.

IXODIDAE. Back covered by a horny shield, head distinct from the body. Anus in middle of ventral side. Skin finely striated. Tarsi with pulvillum. Male almost entirely covered with dorsal shield. Female shield only on anterior part of dorsum.

Ixodes hexagonus. Santa Clara Co., Mt. Shasta.

I. californicus Bks. Laguna Beach, Claremont, Santa Clara Co. On fox and deer, dog. Shield red-brown, paler in middle, body brownish or yellowish, coxae brown, legs paler. Few hairs. Shield long, finely punctured.

I. angustus Neum. Siskiyou Co.

I. sculptus Neum. Santa Cruz Mts., Calif.

I. pratti Bks. Claremont.

Argas miniatus Koch. Large ticks, exact location of capture not known. Calif.

Ornithodoros megnini Duges. Mt. Shasta; also S. Calif.

Dermacentor occidentalis Neum. Mts. near Claremont and foothills.

D. reticulatus Feb. Palo Alto and Mt. Shasta.

D. parumapertus Neum. Lake Side, Calif.

D. occidentalis Neum. Santa Clara Co., Humboldt Co. From deer.

Ceratixodes signatus Birula. Cormorant, Pacific Grove.

Amblyomma maculatum Koch. Tulare Co., Calif.

A. cajennense Beb. San Diego.

Haemapysalis leporis-plaustris Pack. On rabbit, Claremont.

H. concinna Koch. Claremont, on rabbit.

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IXODIDAE A. *Haemaphysalis leporis-palustris,* fresh and gorged female. TYROGLYPHIDAE B. *Carpoglyphus passularum,* C. *Glyciphagus obesus.* ERIOPHYIDAE E. *Eriophyes oleivorus.* TETRANYCHIDAE D. *Tetranychus sexmaculatus,* F. *Tenuipalpus californicus,* G. *Tetranychoides californicus,* H. *Caligonus terminalis,* J. *Tetranychus bimaculatus,* K. *Bryobia pratensis,* L. *Tetranychus mytilaspidis.* ORBATIDAE I. *Eremaeus modestus.* TYROGLYPHIDAE M. *Tyroglyphus americanus.*

VI. Nemertinea

The first work of any importance which deals with the nervous system of these worms is that of De Quatrefages in 1846. He describes the central nervous system as composed of two distinct lateral lobes united below and above by commissures. From the lateral lobes two more or less isolated longitudinal bands extend themselves towards the posterior end of the animal. So far as the figures are concerned this early work is even more detailed than that of M'Intosh in 1873. The more recent information about this interesting group has been furnished especially by Hubrecht in numerous papers from 1875 to 1887. Although the cellular details are not shown, the relative position of the central fibrous core is given in relation to the surrounding nerve cells. He also clearly distinguishes the dorsal median nerve springing from the slender dorsal commissure. The dorsal and ventral lobes of the brain are shown more clearly than in earlier writings. In *Eupolia* a dorsal, middle and ventral lobe are shown.

Hubrecht in his two paoers of 1887 suggests the nemertineans as a group of animals valuable in tracing the relationship of the vertebrates and invertebrates. He bases his hypothesis largely upon the arrangement of the parts of the nervous system. In the group there is some variation in the extent and position of the lateral nerve cords and in some, the mouth opens behind the brain and in some in front of the brain. Such facts as these give suggestions of an intermediate condition between annelids and arthropods on the one side and vertebrates on the other. Other writers have compared the large lateral nerves of nemertineans with the central nerve cords of some round worms.

Bürger in a number of works from 1883 to 1895, has made a considerable study of the nervous system by various methods. He has also studied the histological details of the nervous system. His papers are the most comprehensive and important in this field. Bürger describes the nerve cells as all unipolar and uninclosed in special membranes. He classifies nerve cells as follows: (1) The smallest cells sensory in nature; (2) medium sized cells; (3) large cells; (4) very large cells, the so-called "Neurocorde" cells.

Montgomery, 1897, agrees with Bürger in many respects, such as unipolar condition of the nerve fibers, but these are composed of "a homogeneous unstaining axis cylinder which is probably fluid and a fine spongioplasmic layer."

In *Cerebratulus*, the large nerve fibers differ from the others in size. They do not give off collaterals but divide dichotomously and are arranged segmentally. The largest ganglion cells are present in three pairs in the ventral brain lobes and are distributed irregularly along the lateral cords, but are absent in both ends. In the

lateral cords they increase in number posteriorly and are more abundant on the dorsal side. In each lateral cord both dorsally and ventrally are radial clusters of medium sized cells showing a bilateral arrangement.

Haller, 1889, shows a neuroglia network in *Cerebratulus* and an anastomosis between the branches of multipolar ganglion cells.

The nemertineans are divided into groups somewhat by the position of the nervous system in relation to the body-wall. The more primitive condition seems to be when the brain and chief branches are outside the muscle layers, in the epithelium or below the basement membrane. In some the nervous system is found in the muscle layers of the body-wall and in others the brain and chief nerves lie in the parenchyma internal to the muscle layers.

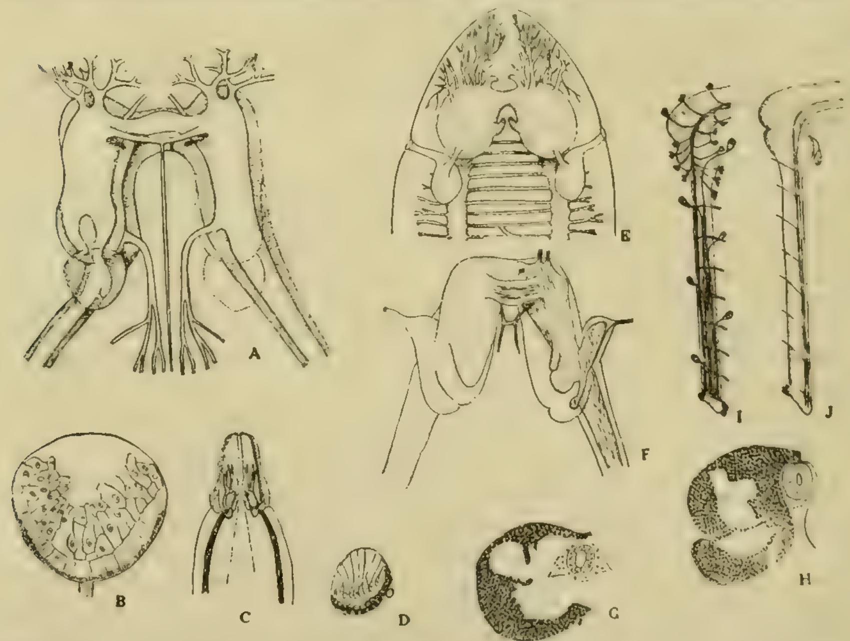

Fig. 13. Nervous system and sense organs of Nemertinea. A. Nervous system of *Cerebratulus* showing chief nerves and the position of the central fibrous mass, Hubrecht. B. Section of eye of *Drepanophorus*, Hubrecht. C. Diagram of head end of *Cerebratulus*. D. Section of eye of *Lineus*, *Punnett*. E. Brain of *Drapanophorus*, Hubrecht. F. Brain of *Eupolia*, showing fibrous core on the right, Hubrecht. G, H. Cross sections through brain of *Eupolia*, left side and oesophagus shown in each. I, J. Scheme of some nerve cells and fibers in the lateral cord and ventral ganglion in *Anopla*, and *Drepanophorus*, Bürger.

Hubrecht, '87, suggests that the more primitive nervous system of these animals has a most complicated intricate network of peri-

pheral nerve tissue. This network suggests the "most ancient arrangement of the nervous tissue." In the more highly specialized forms, the brain and lateral nerves are more concentrated. Probably all nemertineans have more or less peripheral nerve networks even though Hubrecht might not have seen them by his methods, but the fact remains that those forms in which the network is especially marked are more primitive because of it. Montgomery believes that Haller is mistaken as to the multipolar condition of these cells.

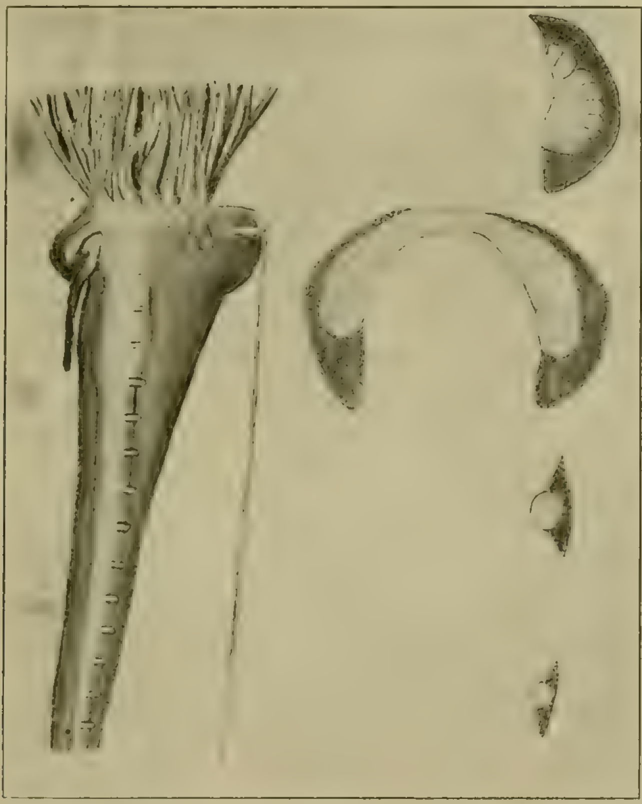

Fig. 14. Reconstruction of the nervous system of *Carinella* shown from the ventral side. Figure at the left, side view of a reconstruction of the upper portion of the central nervous system of *Carinella*. The figures at the right are from cross section taken at various levels. The upper and the two lower figures are from one side only. X75, Hilton.

In general the central nervous system of the Nemertinea is as follows: A brain composed of two ganglionic masses at the anterior end of the body, on on each side of the proboscis. These are united

by ventral and dorsal commissures passing about the proboscis. The dorsal band is often more slender than the ventral and from it a slender dorsal nerve runs the length of the body. Each lateral brain lobe is often partly divided into a dorsal and ventral lobe. From each lateral ganglion a large nerve trunk passes back and may unite with its fellow of the opposite side just above the anus.

Nerves are given off from the brain to the eyes when present, and to anterior portions of the body. Two branches come off from the dorsal commissure and run to the proboscis. The so-called vagus nerves arise from the internal borders of the brain not far from the origin of the lateral cords. They are sometimes united by a commissure and then pass down the oesophagus.

Eyes are usually present along the sides of the head, sometimes a single pair, at other times one or more groups on each side. The eyes in their simplest conditions are mere pigment spots, in others there is a clear area filled with fluid which is supported by strands from cells and held by a limiting membrane. Sensory cells are connected with the brain by fibers and with pigment at the outer side. The sensory area seems to be like rods in certain forms.

In some cases otocysts have been found on the surface of the brain. At the anterior tip of the head groups of cells bear long bristles. In some, these areas are retractile. Taste has been suggested as the function of these "frontal" organs. The so-called "side" organs occur as a pair of epithelial patches on each side of the body in the region of the excretory pore. These have an abundant nerve supply but their function is unknown.

In most forms a peculiar pair of organs is found in the head region in close connection wtih the brain. Hubrecht suggests that they may be respiratory. Bürger thought that they might be organs used for determining the condition of the water. They may be shallow depressions, longitudinal or slit-like or the slit may be at right angles to the body. In some, ciliated ducts pass inwards and penetrate into special lobes called the *cerebral organs*.

Thompson, 1908, in *Cerebratulus lacteus* finds six ventral commissures from the ventral lobes of the brain. Some of these come from the fibrous core and some come from the cellular sheath of the brain. Other commissures are found beyond the brain.

Six pairs of "neurocord" cells and one unpaired cell are found in the ventral lobes of the brain. There is probably individual variation as to their number.

The brain is complex but resembles in its form and commissures that of the tubularian worms.

Coe and Ball, 1920, in *Nectonemertes*, find both dorsal and ventral commissures well developed. Cerebral and frontal organs are lacking.

In the blastula of *Cerebratulus* cells on the apex of the larvae develop cilia and sink below the general surface. This forms the apical sense organ of the larva.

The brain of the adult develops by thickenings of the apical discs.

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A List of California Arachnida

VII. ARANEIDA OR TRUE SPIDERS

M. Moles, I. Johnson

AVICULARIIDAE. Chelicera project forward and claw moves vertically. Two pairs of book-lungs. Coxae of pedipalp like the legs, lacks a distinct endite.

Bothriocyrtum californicum Camb. Los Angeles Co., etc. Common trap door spider.

Eutychides versicolor Simon. Santa Clara Valley.

Hexura picea Sim. Mariposa Co.

Brachythele longitarsis Sim. Calif.

B. theveneti Mariposa Calif.

Atypodes riversi Camb. Black Mt., Calif.

Eurpelma californica Auss. Santa Cruz and south to Claremont.

E. rileyi Mar. Calif.

E. leiogaster Auss. Calif.

E. marxi Simon. Calif.

Hexura fulva Chamb. Claremont.

Nemesoides hespera Chamb. Claremont.

Amblyocarenum talpa Bks. Calif.

Aptostichus atomarius Simon. Calif.

A. clathratus Simon.

A. standfordianus Ch. P. Smith, San Francisco Co.

Avicularia californica Bks. Calif.

Hebestatis thereneti Simon. Calif.

ATYPIDAE. Distinguished from the previous family by more complicated palpus of male. Coxa of pedipalps bears a large conical lobe. They also have a large endite on the coxa of palpus.

Aliatypus californicus Bks. Santa Clara Valley.

ULBORIDAE. Spin orb-webs. Have cribeillum and calamistrum. Dark eyes, lateral ones farther apart than the two pairs of median ones. Posterior metatarsi much curved and armed below with a series of spines.

Ulborus californicus Bks. Napa Co. and near Claremont.

DICTYNIDAE. Cribellum and calamistrum. Anterior median, eyes dark, others white. Lateral eyes on each side nearly touching. Tarsi of legs three claws. Irregular web.

Amaurobius nevadensis Simon. Northern counties.

A. nigrellus Chamb. Claremont.

A. pictus Simon. San Francisco.

Dictyna sublata Hentz. Lake Tahoe to Claremont.

D. volucripes Keyser. Palo Alto to Claremont.

D. calcarata Bks. San Pedro.

D. mians Chamb. Claremont.

Dictynina pallida Bks. Mt. Shasta.

Dictyolathys californica Bks. Palo Alto.

Parauximus tradatus Chamb. Claremont.

Auximus pallescens Chamb. Claremont.

A. latescans Chamb. Claremont.

Filistatidae. Eyes massed in small group, anterior median eyes dark, round, rest oval or angular, white. Chelicerae small without condyle, chelate.

Filistata hibernalis Hentz. Mill Valley to Claremont.

Dysderidae. Six eyes. Four spiracles near base of abdomen. A pair of lung slits and a pair of tracheal spiracles. Coxae of first pair of legs long and cylindrical.

Segestria pacifica Bks. Mt. Shasta and Claremont.

Scytodidae. Six eyes, one tracheal spiracle. All eyes white. No suture between labium and sternum.

Diguetia canites McCook. San Diego, Los Angeles.

Plectreurys suprenans Chamb. Claremont.

Leptonetidae. Six eyes, small long legs, suture between labium and sternum.

Leptoneta californica Bks. Mt. Diablo.

Usoala gracilis Mark. Calif.

Drassidae. Eight eyes in two rows. Two tarsal claws. Four spinnerets widely separated. Tarsi with bundles of terminal tenent hairs.

Drassudes californica Bks. Sierra Co. and Martin Co.

D. celes Chamb. Claremont.

Megamyrmecion californicum Simon. San Francisco, Claremont.

Drassinella modesta Bks. San Francisco and Claremont.

Gnaphosa californica Bks.

Poecilochroa pacifica Bks. Sierra Co., Stanford and Claremont.

P. montana Em. Claremont.

P. concinna Sim. Calif.

Zelotes femoralis Bks. Claremont.

Z. maculatus Bks. Claremont.

Z. pacificus Bks. Santa Rosa I.

Z. taibo Chamb. Claremont.

Z. irritans Chamb. Claremont.

Z. gynethus Chamb. Claremont.

Z. ethops Chamb. Claremont.

Herpyllus augustis Bks. San Pedro.

H. californicus Bks. Lakeside, Calif.

H. validus Bks. Los Angeles and Claremont.

H. pius Chamb. Claremont.

Sergcolus bicolor Bks. Claremont.

Callilepis insularis Bks. Guadeloupe I., Claremont.

PHOLCIDAE. Very long legs, irregular webs. Tarsi of legs three claws, usually eight eyes. Group of three eyes on each side.

Pholcus phalangioides Fuessl. Los Angeles, Claremont.
Physocyclus golbosus Tacz.
Psilochorus californiae Chamb.

ZODARIIDAE. Legs nearly equal in site. Internal face of the endites is not furnished wtih serrula, but bears an apical scopula. Rostrum membranous and furnished above with a band of hairs.

Lutica maculata Marx. Calif.

THERIDIIDAE. Eight eyes. Three tarsal claws, comb on tarsus of fourth pair of legs. Chelicera no condyle.

Theridion tepidariorum Koch. San Francisco, Claremont.
T. placens Keys. Calif.
T. differens Em. Palo Alto, Mt. Shasta.
T. fordum Key. Santa Cruz.
T. californicum Bks. Calif.
T. inconstans Curtis. - Calif.
T. sexpunctatum Emerton. Mill Valley.
T. pictulum Bks. Calif.
Latrodectes mactans Fab. North to south, Catalina I.
Dipoena pictipes Bks. Claremont, Calif.
Argyrodes decorus Bks. Calif.
A. jucundus Camb. Los Angeles, San Pedro.
Euryopis funebris Hentz. San Francisco.
Steatoda grandis Bks. Claremont.
Lithyphantes tectus Keyser.

LINYPHIIDAE. Three claws, eight eyes. No comb on tarsus. Organs of stridulation. Dissimilar eyes. No lateral condyle or chelilerae.

Diplocephalus fasciatus Bks. Calif.
Lniyphia arcuata Keyser. San Francisco.
L. digna Keyser. Palto Alto.
L. phrygiana Koch. Palo Alto.
L. rubrofasciata Keyser. Mt. Shasta.
Erigone californica Bks. N. Calif and Claremont.
Bathyphantes pallidulus Bls. Calif.

ARGIOPIDAE. Orb-weavers. Three claws, eight eyes. Tarsi hairs, no comb.

Tetragnatha extensa Linn. Alameda Co.
T. laboriosa Hentz. N. and S. Calif.
Leucauge hortorum Hentz. Los Angeles.
Argiope trifasciata Forsk.
A. argentata Fsb. S. Calif.
A. aurantia Lucas.
A. avara Thorell. Calif.
Ordgarius cornigerus Hentz. Los Angeles.
Gasteracantha maura McCook. Claremont.

G. cancrifornis Linn. Calif.
G. tetracantha Linn. Calif.
Meta menardi Latrelle. Claremont.
Cyrtophora californiensis Keyser.
Cyclosa index Cambs. N. Calif.
C. conica Pallas. N. to South.
Eustala anastera var. *conchlea* McCook. Calif.
Zella californica Bks.
Z. x-notata Clerck. Claremont.
Metargiope trifasciata Forsk. Claremont.
Aranea angulata Clerck. Claremont.
A. marmorea Clerck. Claremont.
A. curcurbitina Clerck. Claremont.
A. carbonaria Koch.
A. miniata Walck. Claremont.
A. bispinosa Keys. Calif.
A. conchlea McCook. Claremont.
A. oaxacensis Keys. Sitz. Palo Alto to Los Angeles.
A. displicata Hentz. Mill Valley, Mt. Shasta.
A. labyrinthea Hentz. Martin Co. to Claremont.
A. l. grinelli Coolidge.
A. nephiloides Camb.
A. trifolium Hentz.
A. patagiata Clark. N. Calif.
A. pacifica McCook. N. and S. Calif.
A. californica Bks. Calif.
A. gemma McCook. N. to S.
A. variolata Camb. Calif.
A. gosogana Chamb. Calif. desert region.
Leucauge argyra Walck. Calif.

Ctenidae. Wandering spiders, usually. Eyes three to four transverse rows. Ends of endites clothed in dense uneven hairs. Two-clawed.

Titiotus californicus Simon. From Calif.

Clubionidae. Flat tubular nests, eight eyes in two rows, two tarsal claws. Lower margin of furrow of chelicerae distinct, armed with teeth. Tarsi usually with bundle of tenent hairs.

Gayenna californica Bks. Palo Alto, Mill Valley.
Chiracanthium inclusum Hentz. Mill Valley, Claremont.
Clubiona pacifica Bks. Claremont.
Olios fasciculatus Simon. Calif.
O. schistus Chamb. Claremont.
Anyphaena crebrispina Chamb. Claremont.
A. ruens Chamb. Claremont.
A. zina Chamb. Claremont.
A. incursa Chamb. Claremont.
A. nundella Chamb. Claremont.

Anachemmis sober Chamb. Claremont.
A. dolichopus Chamb. Claremont.
Namopsilus pletus Chamb. Claremont.
Micaria palliditarsus Bks. S. Calif.
Castaneira descripta Hentz. Claremont.
C. pacifica Bks.
C. tricolor C. Koch.
Trachelas tranquillus Hentz. Claremont Mts.
T. californicus Bks. Claremont.
Hilke trivittata Keys. Calif.

AGELENIDAE. Three claws, usually eight eyes. No scopula on tarsus. Trochanters not notched. Hind spinnerets very long. Funnel-web weavers.
Agelena pacifica Bks. N. Cal., Catalina I. and Claremont.
A. californica Bks. Stanford, Claremont.
A. naevia Hentz. Claremont and Catalina I.
A. rua Chamb. Claremont.
Tegenaria domestica Clerck. Claremont.
T. californica Bls. N. Calif and Claremont.
Cybaeus reticulatus Simon. Claremont.
C. minor Bks. Claremont.
Chorizomma californica Sim. San Francisco.
Cybaeodes incerta Bks. Salton, Calif.
Coelotes esaptus Bks. Calif.

MIMETIDAE. Tibia and metatarsi of first two pairs of legs with very long spines and shorter between.
Mimetus interfector Hentz. Claremont.

THOMISIDAE. Crab-spiders. First and second pair of legs usually longer than third and fourth. Eyes small dark, two rows usually recurved. Lower margin of chelicerae indistinct, unarmed, upper unarmed or with one to two teeth.
Xysticus californicus Keyser. N. to S.
X. formosus Bks. Mt. Shasta.
X. ferox Hentz. Claremont.
X. gluosus Keyser. Claremont.
X. triguttatus Keys.
X. montanaensis Keys. Calif.
Coriarachne brunneipes Bks. Mt. Shasta.
Runcinia aleatoria Hentz. N. Calif.
Misumena vatia Clark. N. to S.
Misumessus pictilis Bks. Palo Alto.
M. pallidulus Bks. San Francisco.
Misumenoides aleatorius Hentz. Claremont.
M. californicus Bks.
Misumenops asperatus Hentz. Claremont.
M. californicus Bks.
M. importunus Keys. Calif.
M. diegoi Keys. Calif.

M. modestus Bks. Calif.
M. munieri Coolidge.
M. pallidulus Bks.
M. pictilis Bks.
Tmarus magniceps Keys. Los Angeles.
Thanatus coloradensis Keyser. N. and Claremont.
T. retentus Chamb. Claremont.
T. oblongus Walck. Palo Alto and south.
Philodromus rufus Walc. N. Calif.
P. californicus Keyser. N. Calif.
P. moestus Bks. Claremont.
P. pernix Blackwall. Claremont.

LYCOSIDAE. Wolf-spiders. Trochanters of legs notched. Lorum of two pieces one notched to receive the other. Eyes in three rows, posterior lateral eyes behind posterior median, first row of four small eyes, two back rows of two large eyes each.

Lycosa pacifica Bks. N. to Claremont.
L. brunneiventris Bks. Palo Alto, Claremont.
L. kochi Keys. Claremont, and Ontario Mt.
L. ferriculosa Chamb. Claremont.
L. piratimorpha Strand. Calif.
L. ramulosa McCook. Calif.
Pardosa sternalis Thorell. Claremont.
P. lapidicina Em. Claremont.
P. tuoba Chamb. Claremont.
P. californica Keys. N. Calif. and Claremont.
P. modica Blackw. Mill Valley, Mt. Shasta.
Sossippus californicus Simon. Claremont.
Pirata californicus Bks. Mariposa Co.

OXYOPIDAE. Legs long, three tarsal claws, no scopulae. Trochanters not notched. Eight eyes, dark. Anterior median eyes very small. Abdomen tapers to a joint behind.

Peucetia viridans Hentz. Los Angeles.
Oxopes salitcus Hentz. Mill Valley, Palo Alto.
O. rufipes Bks. Mt. Shasta, Santa Clara.

ATTIDAE. Jumping spiders. Short body, stout legs, two tarsal claws, bright colors, conspicuous eyes.

Dendryphantes capitatus Hentz. N. Calif.
D. californicus Peck. Calif.
D. vitis Peck. Claremont.
D. femoratus Peck. Calif.
D. johnsoni Peck. S. Calif., Catalina I., Claremont.
D. guttatus Bks. Calif.
D. ardens Peck. Calif.
D. aeneolus Curtis. Palo Alto.
D. hartfordi Peck. Claremont.
D. nubilus Hentz. Calif.

D. opifex McCook. N. and Los Angeles Co.
Thiodina retarius Hentz. N. and S. Calif.
Pallenes signatus Bks. Los Angeles.
P. elegans Peck. San Pedro.
P. tarsalis Bks. San Pedro.
P. dolosus Peck. Calif.
P. californicus Bks. Calif.
P. griseus Peck. Calif.
P. pacificus Bks. San Francisco.
P. jucundus Peck. Calif.
P. speciosus Bks. Claremont.
P. hutchensoni Peck. Calif.
Epiblemum palpalis Bks. Palo Alto.
Metacyrba taeniola Hentz. Los Angeles, Claremont.
Marpissa melanognatha Lucas. N. Calif.
M. californica Peck. N. Calif.
Salticus scenicum Clerk. Santa Barbara I.
Attus dorsatus Bks. S. Calif.
Sidusa morosa Peck N. Calif.
Sitticus claremonti Peck. Claremont.
Sassacus papenhoei Peck. Calif.
Attinella dorsata Bks. Calif.
Pseudicius siticulosus Peck. Calif.
Habrocestum morosum Peck. Calif.
Hyctia robusta Bks. Calif.

Trap-door spid. ii, 1874, p. 260. Simon List. des osp. 1892, p. 14. Bul. Soc. Z. Fr. 1884, p. 12, 13, p. 316. Ann. Ent. Soc. Fr. 1883, p. 86, 1891, p. 305, 1893, p. 308. Proc. Zool. Soc. London. 1880, p. 326, 1883, p. 355. Jour. N. Y. Ent. Soc. 1893, p. 133, 1884, p. 50, 1896, p. 88-110,, 1904, p. 12, 117-118. Ges. Wien. 1871, p. 214. Proc. Calif. Ac. Sc. 1898, p. 279, 1904, p. 333, 342. Hentz. Spid. U. S. 1875, p. 24, 147. Verh. Zool. bol. Ges. Wien. 1881, p. 286. Canad. Ent. 1891, p. 209. Cook. Spid. U. S. 1892. Trans. Conn. Ac. Sc. VI, 1882, p. 9-12, VIII, 1890, p. 11. Trans. Am. Ent. Soc. 23, 1896, p. 59-65. Canad. Ent. 1900, p. 97-99, 1898, p. 185. Fuessl. Verz. D. schw. Ent. Ross. X, 1874, p. 105. Koch Die Arach. VIII, 1849, p 75. Keyserling Spinn. Am. Thrid. 1884, p. 71—. Proc. Ac. Nat. Sc. Phila. 1878, p. 276, 1888, p. 193, 1892, p. 56, 1901, p. 5-78. Linn. Syst. Nat XI, p. 621. Fab. Ent. Syst. II, 1793, p. 414. Biol. Cent. Am. Arach. 1, p. 51, Spicilog. Zool. 1, 1872, p. 48. Itz. Isis Dresden, 1863, p. 121. Pomona Jour. Ent. VII, No. 3, 1910. Act. Soc. Linn. Bordeaux 1880, p. 307. Ent. Carnioli 1873, p. 400. An. Soc. Ent. Belg. 1886, p. 56, 1898, p. 25. Bull. Soc. Zool. Fr. 1895, p. 136. Thorell. Spid. Greenland. 1872. Fab. Ent. Syst. II, 1793, p. 423. Peckham, Attidae 1883, p. 22. The Entomologist 1894, p. 207. Zoe. 1892, p. 332, 1888, p. 81. Trans. Wis. Ac. Sc. 1900, p. 220. Hist. Nat. d'Iles. Canar, 1839, p. 29. Oc. Papers, Wisc. N. H. Soc. II, 1895, p. 177. Jour. Ent. Zool. 1915, p. 209, 1916, p. 112, 1918, p. 1, 1920, p. 1-23, p. 25. Synoptic Index-Catalogue of Spiders of N C. and S. America. A. Petrunkevitch Bul. Am. Mus. Nat. Hist. V. 29, 1911.

Ophiuroidea of the West Coast of North America

ARTHUR S. CAMPBELL.

This list represents those Ophiuroidea reported upon by H. L. Clark, J. F. McClendon, and others, at various times from the West Coast of North America, and especially from the coast of California. Specimens listed are mostly from deeper water; but a few are littoral.

Original references to each species are given as far as possible. Bathymetrical ranges given are either extremes or are the only point from which specimens are known.

There seem to be several restricted faunas represented in the list. It is quite possible that specimens of almost any of the list might be taken at other points off the coast, and thus extend the known range.

The purpose of the list is to clear up certain synonyms, to check the present literature so far as possible, to record more complete data concerning the distribution of forms likely to be taken nearby, and to know more thoroughly what we have.

Our work is by no means finished, but we feel the list may be of some aid to those undertaking the study of west coast forms.

OPHIURAE

OPHIODERMATIDAE.

Ophioderma panamensis Lütkin. Add. ad Hist. Oph., 2, p. 193. 1859. Littoral. Panama to California.

Ophioderma variegata Lütkin. 1859. Add. ad Hist. Oph., 2, p. 21. Littoral. Lower Calif.

Ophiocryptus maculosus Clark. 1915. 3d. Laguna Rep., Pomona Coll., p. 64. Littoral. Laguna, Calif.

Diopederma axiologum Clark. 1915. Ech. Lower Calif., p. 206. pl. XLV, fig. 5-7. Am. Mus. N. Hist., vol. 22, art. 8, pp. 185-236. Coast. Cape St. Lucas.

OPHIOLEPIDAE.

Ophioplocus esmarki Lyman. Bull. M. C. Z. 3, pt. 10, p. 227, p. 5. Shore-40 faths. Panama—north.

Ophiocten pacificum L. & M. Mem. M. C. Z., 23, no. 2, 1887. 0-1573 faths. San Diego southward.

Ophiomusium jolliensis McClendon. U. C. pub. Zoo., vol. 6, no. 3, p. 36. 1909. La Jolla, Calif. 85-330 faths.

Ophiomusium lymani W. Thos. "Dep. of the Sea", p. 172, figs. 32-33. 600-1,101 faths. Cosmopolitan.

Ophiomusium glabrum L. & M. Mem. M. C. Z., vol. 23, p. 132. 480-2,232 faths. Equator-47° N.

Ophionereis adspersus Lyman. Bull. M. C. Z., vol. 10, p. 236. 647 faths. Lower Calif.

Ophionereis polyporus L. & M. Mem. M. C. Z., vol. 23, p. 109. 491-647 faths. Lower Calif.

Ophionereis annulata Le Conte. Proc. Acd. N. Sc. Phila., p. 317. 1851. Shore-35 faths. California.

Ophiura flagellata (Lyman) Meissner. 1901. Das Thierreich, vol. 2, pt. 3, p. 925. 735 faths. Lower Calif.

Ophiura superba (L. & M.) Meissner. 1901. Das Thierreich, vol. 2. pt. 3, p. 925. Lower Calif.-northward. 451-930 faths.

Ophiura irrorata (Lyman) Meissner. Das Thierreich. vol. 2, pt. 3, p. 925. 1,760 faths. Lower Calif.

Ophiura ponderosa (Lyman) Meissner. 1901. Das Thierreich. vol. 2, pt. 3, p. 925. 640 faths. Lower Calif.

Ophiura ogliopora Clark. Ech. Lower Cal., p. 210, pl. 45, figs. 8-9. M. N. Hist., pp. 185-236, 1913. 630 faths. Cape St. Lucas.

Ophiura sarsii Lütkin. Vid. Medd. for 1854, 1885, p. 101. 5-695 faths. Cosm.

Ophiura leptoctenia Clark. Bull. U. S. N. M., no. 75, p. 51. 1911. 67-1,771 faths. Northward.

Ophiura cryptolepis Clark. Bull. U. S. N. M., no. 75, p. 69. 1911. 230-636 faths. Northward.

Ophiura lütkini Lyman. Proc. Bost. Soc. N. Hist., 8, p. 197. 1860. California to Puget Sound. 22-600 faths.

Ophiura kofoidi McClendon. U. C. pub. Zoo., vol. 6, no. 3, p. 38. 1909. 80 faths. San Diego.

Ophiura brevispina (Say) Lyman. "Challenger", Zoology, vol. 5, p. 9. Deep Water. Puget Sound.

AMPHIURIDAE.

Amphiodia barbarae Lyman. Ill. Cat. M. C. Z. Harvard, 8, pt. 2, p. 17, pl. 3. Shore-100 faths. Deep in sand. California.

Amphiodia strongyloplax Clark. Smith. Bull. 75. 1911. p. 164. 171 faths. Washington.

Amphiodia urtica Lyman. Proc. Bost. Soc. N. Hist., vol. 7, 1860. p. 195. 15-50 faths. Calif-Alaska.

Amphiodia occidentalis Lyman. Proc. Bost. Soc. N. Hist., vol. 7, 1860. p. 194. Coast. Monterey-Alaska.

Amphiodia periercta Clark. Smith. Bull. no. 75. 1911. p. 160. Oregon-Alaska. 8-240 faths.

Amphiodia dalea Lyman. 1879. Bull. M. C. Z., vol. 6, p. 27. 1,076-1,760 faths. North.

Amphiodia euryaspis Clark. Bull. U. S. N. M. no. 75, p. 158. 68-318 faths. North.

Amphiura diastra McClendon. U. C. pub. Zoo., vol. 6, no. 3, supp. San Diego. 100 faths.

Amphiura carchara Clark. 1911. Bull. 75, U. S. N. M., p. 142. 1,090 faths. Northward.

Amphiura diomedeae L. & M. 1899. Mem. M. C. Z., vol. 23, p. 151. 640-659 faths. Monterey-Southward.

Amphiura serpentina L. & M. Mem. M. C. Z., vol. 6, p. 143. 1899. 475-645 faths. North.

Amphilimna pentacantha Clark. Smith. Bull. 75. 1911. p. 172. 48 faths. Calif.

Amphipholis pugetana Lyman. Proc. Bost. Soc. N. Hist., vol. 7. 1868. p. 193. 8-240 faths. Monterey-North.

Amphipholis puntarenae Lütkin. Bidrag til Kundskab. om Slagestjerne, 3 Vidensk. Meddel. Naturhist. Foren: Kojobenh. 1856. La Jolla. 10-50 faths.

Ophiocnida hispida Le Conte. Proc. Acad. N. Sc. Phila., 5, p. 318. 1851. Shore. Panama-Catalina.

Ophiocnida amphacantha McClendon. U. C. pub. Zoo., vol. 6, no. 3. 1909. p. 46. 120-150 faths. San Diego.

Ophiopholis aculeata Linn. Syst. Naturae, 12th Ed., 1767, p. 1101. 9-372 faths. Puget Sound-North.

Ophiopholis aculeata kennerlyi Lyman. Proc. Bost. Soc. N. Hist., vol. 7, 1860. p. 200. 8-238 faths. Calif.-Alaska.

Ophiopholis bakeri McClendon. U. C. pub. Zoo., vol. 6, no, 3, p. 41. Southern Calif. 60-215 faths.

Ophiactus arenosa Lütkin. Bidrag til Kundskab om Slagestjerne, 3, Vidensk. Meddel. Naturhist. Foren: Kojobenh. 1856. in sponges, Lower Calif.-South.

OPHIOCOMIDAE.

Ophiocoma aethiops Lütkin. 1859. Add. ad Hist. Ophiu., pt. 2, p. 145. Coast. Lower Calif.

Opiocoma alexandri Lyman. Proc. Bost. Soc. N. Hist., vol. 7, p. 256. Coast. Lower Calif.

Ophiopteris papillosa Lyman. Ill. Cat. M. C. Z., 8, pt. 2, p. 11, 1875. Shore-30 faths. California.

OPHIOCANTHIDAE.

Ophiocantha rhachophora Clark. Smith. Bull. no. 75, p. 201. 451-630 faths. Bering Sea-Lower Calif.

Opiocantha normani Lyman. Bull. M. C. Z., 6, no. 2, p. 58. 1851. 600 faths. East and West Pacific.

Opiocantha bairdi Lyman. 1883. Bull. M. C. Z., vol. 10, p. 256. 451-525 faths. North.

Opiocantha bathybia Clark. Bull. U. S. M. no. 75, p. 232. 1911. 868-1,090 faths. West Pacific.

Opiocantha moniliformis L. & M. 1899. Mem. M. C. Z., vol. 23, p. 171. 284 faths. Panama-Lower Calif.

OPHIOTHRICIDAE.

Ophiothrix spiculata Le Conte. Proc. Acad. N. Sc. Phila., v., p. 318. 1851. Shore —100faths. Alaska-Panama.

Ophiothrix rudis Lyman. Bull. M. C. Z., pt. 10, p. 239. 1874. Shore—La Jolla.

OPHIOMYXIDAE.

Ophiocynodus corynetes Clark. Smith. Bull. 75, p. 274. 345-685 faths. Washington.

EURYALAE.

ASTEROCHEMIDAE.

Astrochema sublaeve L. & M. 1899. Mem. M. C. Z., vol. 23, p. 187. 534 faths. Lower Calif.

Asteronyx dispar L. & M. 1899. Mem. M. C. Z., vol. 23, p. 185. 491-1101 faths. Lower Calif.

ASTEROPHYTIDAE.

Asteronyx excavata L. & M. Mem. M. C. Z., vol. 23, p. 185. 491-525 faths. Lower Calif.

Asteronyx loveni M. & T. 1842. Syst. Ast., p. 119. 284-659 faths. North-Lower Calif.

Gorgoncephalus eucnemis M. & T. Syst. Ast., 1842. 160 faths. Laguna-North.

Gorgoncephalus caryi Lyman. Proc. Bost. Soc. N. Hist., vol. 7, 1860, p. 424. 8-576 faths. San Francisco-Northward.

(Contribution from the Zoological Laboratory of Pomona College.)

VII. Round Worms

NEMATOIDEA. The central nervous system of nematode worms was early described as a whole by Bütschli who recognized a collar of nerve cells and fibers and longitudinal strands. Hesse, 1892, gives a clearer picture of the nervous system of *Ascaris* and others since that time have improved and elaborated upon these and other early suggestions. Especially noteworthy are the works of Goldschmidt, 1908-9, and Deineka, 1908, each very valuable although the two investigators disagree on many points.

The nervous system of *Ascaris* may furnish a good starting point in a discussion of the nervous system of the group. In this genus there is a circumoral ring about the pharynx near the anterior end of the body. Ganglion cells are not abundant. They are chiefly grouped about the origin of the nerves. The nerve ring gives off six or more longitudinal nerves of which the mid-dorsal and mid-ventral are usually the largest and are connected to each other by fine branches. At the caudal end the lateral nerves pass into two branches formed by the division of the ventral nerve. Just above this point the ventral nerve swells into the anal ganglion. In the male the anal ganglion gives off two lateral nerves which form a ring about the cloaca.

The nerve ring forms a plexus according to Goldschmidt, in that all fibers are connected to other parts, but the plexus is regular and not of the diffuse type as found in Coelenterata. Three cell types are found, sensory, association and motor. Besides the direct connection of cell with cell through their processes there is in places a true neuropile. Neuroglia cells are found but are not prominent. Deineka favors the neropile method of interrelation more than Goldschmidt. This author also has demonstrated the neurofibrillar arrangement of the material with the nerve cells and has shown rather elaborate interrelations between the fibrils of associated cells. He shows nerve terminations in muscle and sensory endings in the skin of the body. Aside from the general surface of the body the three papillae about the mouth are the only sense organs. These are supplied by six short nerves running from the nerve ring.

With free living nematodes but little has been done. In *Enoplas* Hilton, 1920, a very marked head ganglion above the mouth has two strands running backwards to the thick mid-ventral nerve strand and from the dorsal side a slender dorsal nerve runs the length of the body. The ganglion is rather complex in structure. From an inner group of nerve cells, fibers run forward to the sensory epithelium of the tip of the snout and three eyes, one dorsal and two ventro-lateral are composed of pigment and clear area in front.

Magrath, 1919, in *Callanus*, gives a good account of the nervous system of this simple nematode. In this as in other forms, there is

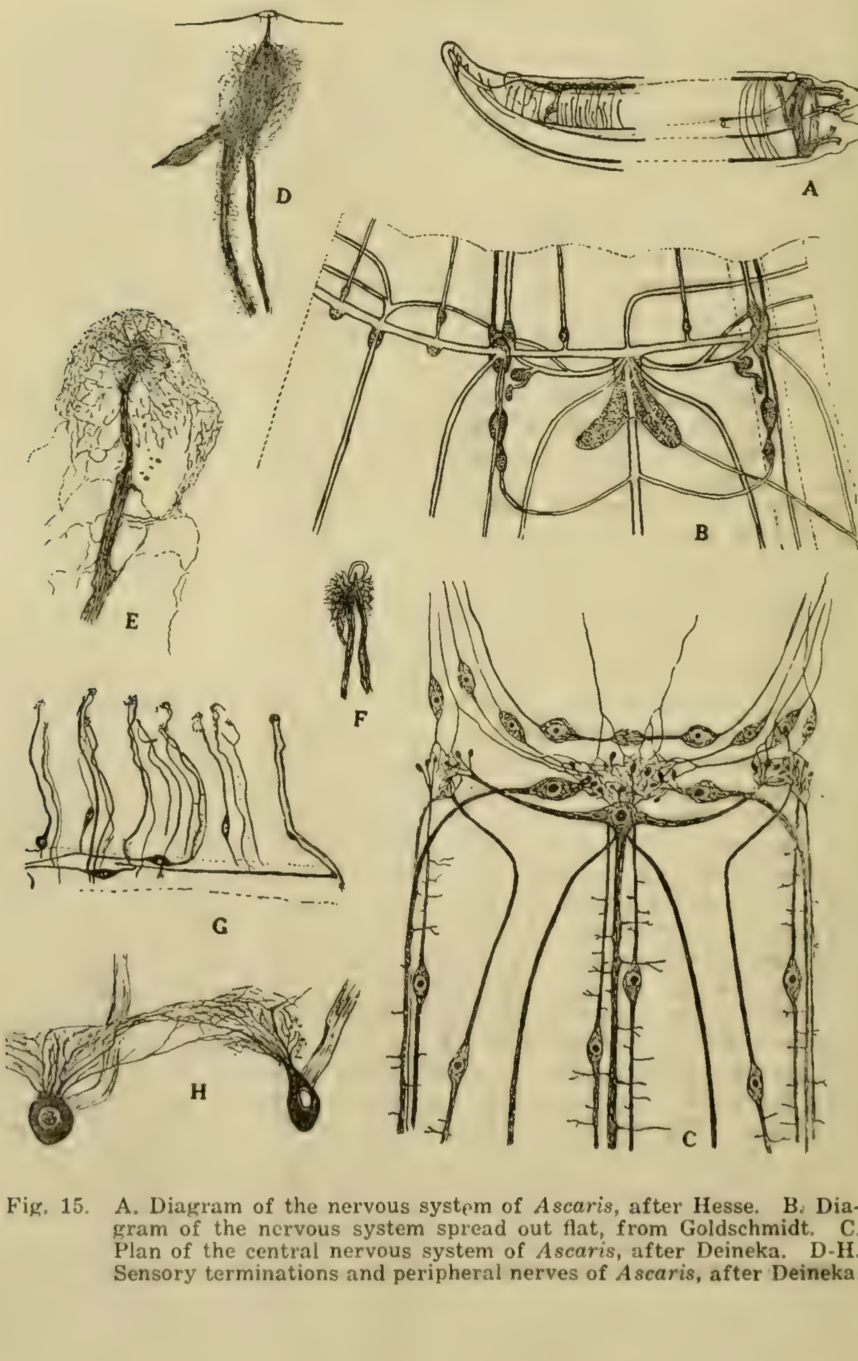

Fig. 15. A. Diagram of the nervous system of *Ascaris*, after Hesse. B. Diagram of the nervous system spread out flat, from Goldschmidt. C. Plan of the central nervous system of *Ascaris*, after Deineka. D-H. Sensory terminations and peripheral nerves of *Ascaris*, after Deineka.

a cephalic commissure. With this are associated twenty nerve cells on each lateral half and a large number just anterior to it. From these last groups six slender nerves pass forward close to the oesophagus to supply the anterior region. The two sub-ventral have small ganglia upon them. Connected with the caudal edge of the nerve ring are four chief ganglia, one dorsal, one ventral and two lateral. Each of these has long strands extending towards the tail

Fig. 16. The figure above is a reconstruction of the head end of *Enoplus*, showing the position of the nervous system. The lower figure at the left is of a section through the whole body of the worm, showing the dorsal and ventral nerve bands. Both these figures enlarged 75 times. The drawing at the right is from a section through the head ganglion, enlarged 170 times. The dorsal side is up in all the figures. Hilton.

end of the animal. Continued from the ventral and separated a little distance is another ventral ganglion, the post-ventral. The dorsal cephalic ganglion is the smallest; the lateral cephalic ganglia are the largest. As pointed out by others the cephalic commissure or nerve ring is essentially fibrous. The fibers are derived from the ganglia connected with it.

In the female the central anal ganglion is the largest. It connects with smaller lumbar ganglia out laterally and by a loop with the rectal ganglion.

In the male the anal ganglion is large, but the two lumbar are nearly as large. Two rings of nerves are connected with the anal ganglion and one with the small cloacal, and the other with the rectal ganglion.

GORDIODEA. Villott, 1874, shows that the ventral cord represents the central nervous system with an anterior and posterior

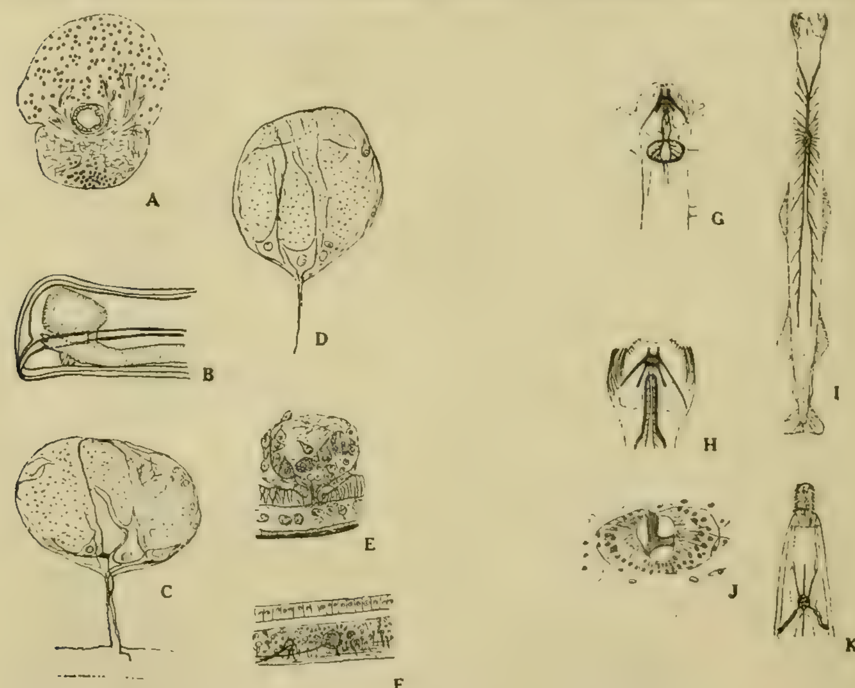

Fig. 17. A-F. Nervous system of Gordoidea. A. Section through brain and suboesophegeal band, much changed from Montgomery. B. Position of supra and suboesophageal ganglion modified from Montgomery. C. and D. Sections of ventral cord. E. and F. Cross and longitudinal sections of the ventral cord after May. G and H. Head of *Chaetognatha* after Hertwig, showing brain, sense organs and chief nerves. I. Ventral ganglion shown, Hertwig. J. Eye of *Chaetognatha.* K. Ganglion in body of *Acanthocephalia* after Leuchart.

ganglion. In 1887 he traced fibers from the head ganglion into the thickened hyrodermis of the head. Vejdovsky, 1883, 1894, considers that there is no cerebral ganglion and no ganglion cells on the dorsal side of the peripharyngeal ganglion. He distinguishes neuroglia cells.

Ward, 1892, on *Nectonema*, a pelagic marine form, gives an account of the nervous system. The anterior ganglionic mass or brain forms a large portion of the floor of the anterior chamber. The oesophagus lies in a groove in its center. There is but a slight dorsal commissure above the oesophagus. The ganglion cells are not abundant in the brain. A smaller kind is more abundant than another sort which is very much larger. There are five pairs of these last which are nearly constant in position and form. The ventral nerve cord continues from the brain and runs the length of the body separated into three areas to correspond to the three nerves of which it is composed. Some large cells in the cord are much like those in the brain. In the male the ventral cord is much enlarged, being larger than the brain itself. In the female the anal ganglion is but slightly larger than the central cord with which it is connected.

Camerano, 1897, considers the nervous system to consist of a supraoesophegeal ganglion and a ventral nerve strand. Montgomery, 1903, finds a ventral unpaired nerve trunk with the cephalic ganglion at its anterior enlargement and the caudal or cloacal ganglion, a posterior enlargement. To the peripheral nervous system belong the neural lamella; the endings in the hypodermis of the fibers of nerve cells situated in the central nervous system; the hypodermal longitudinal nerve; sensory cells in hypodermis; non-sensory hypodermal nerve cells and the nerve fibers which innervate the cloaca of the female and the vasa defferentia of the male. Two types of cells were found in the nerve cord. One type contained but little chromatin. These cells on the lateral sides of the cord are quite uniform and small. On the ventral side there are smaller and larger cells of this type. The larger or giant cells are less numerous. Sometimes there is a paired arrangement of these cells but usually they are irregularly placed one behind another. These cells seem to be bipolar with two large processes proceeding from the cell directed towards the fibrous core of the nerve cord. Some of the small cells appear to be bipolar or multipolar. All cells are without membranes. Montgomery thinks that these deeply staining cells are probably motor and visceral in function.

The deeply staining cells seem to be multipolar with very long processes. It could not be determined whether there was anastomosis of the processes. These cells seem like the multipolar neuroglia cells of other invertebrates but processes pass into the hypodermis.

The ventral cord seems to be made up of three converging rays of fibers but each lateral ray is made up of several distinct fiber tracts. The median tract is the largest and is made up of longitudinal fibers which are closely arranged. Very rarely are nerve

cells found on the dorsal side of this tract. They are most abundant at its ventro-lateral angles.

On each side of the median tract are three not sharply marked portions; (a) a dorsal tract mostly of deep staining fibers, (b) a latero-ventral tract bounded by a layer of clear cells, a tract mainly made up of longitudinal dark fibers, (c) a medio-ventral tract larger than the last and between it and the median. It contains dark fibers running in all directions but mainly longitudinally and also clear fibers.

The nerve cells send their fibers in radially. The "Punktsubstanz" is composed of fibers from two kinds of nerve cells.

The nerve cord has no neural sheath but is immediately surrounded by a small-celled parenchyma. Outside of the outer nerve cells of the cord is a sheet of dark staining fibers.

At intervals along the nerve cord are transverse commissures of fibers extending from the dorso-lateral angle of one side to that of the other. There is no segmental grouping of the nerve cells. The transverse commissures also are not metameric as they are too irregular and too close together.

The so-called cephalic ganglion is a slightly enlarged anterior end of the nerve cord. It is more thickened from side to side than dorso-ventrally. The nerve cells are numerous but limited to the median line. In the head the fiber tracts appear like a large median one each side of the middle line. There is a transverse commissure near where the cephalic nerves meet. As this is on the ventral side it has been called the ventral commissure. According to Montgomery there is no brain or supra-oesophageal ganglion.

The cloacal ganglion of the female is the enlarged posterior end of the ventral nerve cord just anterior to the point where the lateral lobes branch. From the ganglion there are anterior and posterior cloacal nerves.

The cloacal ganglion in the males is not so sharply limited as in the female. The length of the ganglion varies in different individuals of the same size. Small nerves pass to the vasa deferentia. The ganglion divides into a right and left caudal nerve into the caudal lobes.

In both sexes the neural lamella attach the nerve cord to the hypodermis. It is itself of hypodermal nature. At the point of the attachment of the neural lamella, the hypodermis is conical on cross section. There is a clear area here in which the longitudinal hypodermal nerve is located. It is composed of nerve fibers from dark nerve cells of the ventral cord. This hypodermal nerve runs as far as the central nervous system.

Fibers enter the hypodermis by way of the neural lamella apparently from cells in a ventral position. Upon entering the

hypodermis some run longitudinally in the hypodermal nerve or along the sides of the body.

There are two main types of sensory cells in the hypodermis, small irregular cells staining deeply and the elongated cuticular cells of the mid-ventral line. Motor cells are considered to be the clearer ones of the nervous system, the darker straining cells the sensory ones. These last run into the hypodermis.

Linstrow, 1889; Ward, 1892; and Montgomery, 1897, have found structures in the anterior part of the head which may be an eye or possibly a part of the head ganglion.

May, 1919, recognizes more clearly than Montgomery a ring of nervous tissue in the head region. In *Gordius* the brain is outlined at the first as a ring of cells in the hypoderm of the proboscis. It soon separates remaining connected only at the anterior end and ventral side. At first it consists of a few large cells which surround the larval muscles. These large cells remain in this position while the rest of the brain develops in front. The ventral cord arises as a thickening of the hypoderm, but later separates from it. The cells that make up the nerve cord at first appear as two rows of nuclei on the ventral side of the larva. The larger cells seem to be bipolar, giving off one fiber to the longitudinal tract and one to the dorsal border of the cord.

The brain of *Paragordius* develops later than that of *Gordius*. In the first genus the cells of the lamella are located in the ventral cord while in *Gordius* it consists of a series of cells. According to May the mass of cells which Montgomery calls retina is the larger part of the cephalic ganglion.

The reactions of gordioid worms is slow and of a primitive nature. The grasping reaction of the male when in contact with the female is the most definite. If a specimen is at rest it usually requires several successive stimuli to cause even a slight movement of the body. There seems to be no distinct response to light.

ACANTHOCEPHALIA. In this group the nervous system is found to be a single ganglion of large cells located on the surface of the proboscis near its base and two small ganglia in the male which supply the reproductive organs. The larger cephalic center gives off nerves to the proboscis in a cephalic direction and through the lateral retractor muscles on each side caudally strands run out to supply the body-wall. There are no sense organs known.

CHAETOGNATHA. In Sagitta the nervous system consists of a cerebral ganglion in which eyes are situated. A large ventral ganglion is situated about one-third or one-half of the way down the body. Oesophageal conectives join these two chief ganglia. Fibers run from the head ganglion to the jaws and sense organs of the head region and two other small ganglia have been described near the

mouth. From the large ventral ganglion many branches run to lateral and caudal regions of the body. This ventral ganglion is the chief one from the standpoint of size.

Many papillae on the surface of the body probably serve as organs of touch. The eyes, one on each side of the dorsal region of the head are globular and each contains three biconvex lenses separated by pigment and surrounded by rod-like sensory cells. About the dorsal part of the head end there is a ring-like ridge bearing modified ciliated cells. This has been called the olfactory ring.

In *Sagitta*, a great proliferation of cells in the head region of

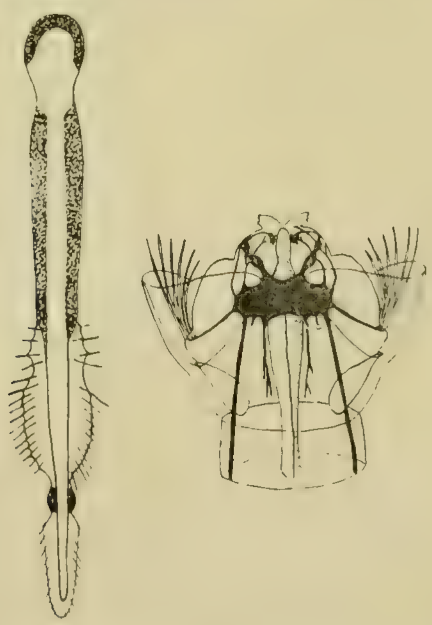

Fig. 18. The sketch at the right is an outline of a larval *Sagitta* showing the position of the origin of the two chief ganglia and the lateral sense organs. All are indicated by the darker shaded areas. The figure at the left shows the position of the chief head ganglia of *Sagitta.*

the elongated larva forms the brain. This is added to on each side by two lateral ridges which later unite to form the cephalic hood. The ventral ganglion begins as a thickening of the ectoderm from behind the head about two-thirds of the length of the body. A tactile organ is developed from ectoderm on each side of the tail region

a little distance from its end. At a later time a double curved line of nuclei forms a horse-shoe shaped area, the so-called olfactory organ.

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